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Fining

Part I

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A. DEFINITION OF FINING

"Fining of Glass" means:
the expulsion of bubbles arising from fusion and remaining in the glass mass;
the elimination of a part of the gases maintained in solution in the glass;
the homogenization of the glass.

These three phenomena: expulsion of bubbles, elimination of dissolved gases and homogenization are closely related to one another: the bubbles which come to the surface of the glass take away by diffusion a part of the dissolved gases and contribute to homogenization by the movement which they cause in the glass.

A characteristic of fining is the gas evolution which is produced in the glass upon melting at elevated temperatures, brought about, for example, by fining agents. As a result of this gas evolution, new bubbles can be formed; moreover, these gases diffuse into the existing bubbles and force the latter to escape from the glass bath.

Loeffler[1] divides the complete glassmelting process into four parts:

1. Reactions within the body of the vitriable mixture, sintering with the formation of sodium and calcium silicates;
2. Fusion itself and principally the dissolution of the sand into the silicates which are initially formed;
3. Fining;
4. Cooling down to the working temperature.

The individual phenomena interact with one another in many ways. The quantity of dissolved gas in the glass depends upon the conditions of the melting process, and the expulsion of bubbles which is incumbent to fining, is, to a great extent, completed only at the time of the cooling phase. Therefore, fining can only be described in relation to the other phenomena.

A glass is designated as "well fined" when it is free or nearly free of bubbles. The gas content of such a glass can be relatively high: it plays no role in the estimation of the state of fining.

B. DESCRIPTION OF THE FINING PROCESS

1. Gas Content of the Glass Mass During Fusion

Glass contains, after fusion is completed, large quantities of gas in the form of bubbles. Jebsen-Marwedel[2] has estimated the proportion of bubbles in a window pane which has just been melted at a maximum of 10 per cent of the volume.

The bubbles contain: carbon dioxide as a result of the decomposition of sodium and calcium carbonates, SO_3 and O_2 coming from sulfates and the usual fining agents, as well as water vapor coming from the moisture in the glass batch. The air which was trapped in the spaces between the grains of the batch must be considered here as well, but the quantity is small as shown by Dietzel[3]. One kilogram of batch contains only 0.2 litre against

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about 60 litres of carbon dioxide.

No special data are given for the types and quantities of gases which are trapped in the bubbles from a batch which has just been melted.

It should be pointed out that the gases which are evolved from the batch during melting and fining have a volume more than a hundred times greater than that of the finished glass. A glass which is half bubbles by volume is designated as "foam". Although the greater part of the gas from the batch may be evolved during fusion, it is remarkable that this gas evolution is produced without or nearly without the formation of foam. Thus, the relatively long time that proper fining requires can be explained. In this respect it is well to not lose sight of Jebsen-Marwedel's[4] observations that a glass batch during fusion (for drawn flat glass) does not possess at any time a quantity of bubbles greater than an amount equivalent to 0.016 per cent by weight of SO_3 even though it can contain, in the dissolved state, up to 1 per cent SO_3. Thus, only a fraction of the total gaseous mass appears in the form of bubbles.

Besides the gases which are visible in the form of bubbles, glasses which have just been melted still retain large quantities of gas in the dissolved state. In order to measure the gas content of a melted glass, "finished" glasses have been heated in a vacuum furnace and their evolution determined. Unfortunately, up to the present time, there has been only a little work establishing the quantity and the nature of the gases evolved during melting and fining or the quantity of gas which remains in the glass of each of these successive stages.

However, for the evolution of SO_3 alone there are a large number of observations. The first considerations on the amount of gas in a glass melt are based on the observations of Gelstharp[5] which allow one to conclude that fined glasses can contain up to 1 per cent SO_3. Research orientated toward the amount of gas in glasses has been carried out by Washburn, Footit and Bunting[6]. They found in some glasses amounts of 4.5 to 83 per cent by volume, corresponding to amounts of 0.0025 to 0.048 per cent by weight of O_2 and amounts of 5 to 27 per cent by volume corresponding to 0.0039 to 0.021 per cent by weight of CO_2.

The question was studied more in detail by Salmang and Becker[7, 8, 9]. These men determined the amounts of water vapor, carbon dioxide, oxygen and SO_3 in the finished glasses. They found in carbonated glasses a proportion of CO_2 in the order of 0.01 per cent by weight, or 0.05 cm^3/g; H_2O: up to 0.05 per cent by weight, corresponding to 0.65 cm^3/g, and a smaller quantity of O_2. The amount of gas in sulphate glasses was shown to be incomparably greater. Thus, up to 0.02 per cent by weight of CO_2 (0.1 cm^3/g) has been found, 0.3 per cent SO_2 (0.9 cm^3/g), up to 0.06 per cent CO_2 (0.4 cm^3/g) and 0.04 per cent H_2O (0.5 cm^3/g).

Salmang and Becker studied in detail, in their research, how gases were retained by the glass, and if it was a question of chemical bonding or of solution. They arrived at the conclusion that gases such as oxygen, nitrogen and the carbon dioxide are not soluble in glass, although this solubility exists without any doubt for water vapor. In addition, they established clearly that gases are retained by the glass when under the special conditions of the moment a stable arrangement can be produced.

Dietzel[3] explains these facts by saying that oxygen, for example, can be retained only when the glass contains divalent iron (FeO), divalent manganese (MnO) or other metals that can link it chemically in such a way as to form Fe_2O_3, Mn_2O_3, etc. Otherwise, oxygen cannot be dissolved in the glass. In the usual colorless glasses which do not possess any element of multiple valency, no solubility of oxygen in the glass batch during fusion is established. Water vapor, as Becker and Salmang mention, can, on the other hand, decompose in glass resulting in a chemical combination which corresponds to the formation of OH groups according to the equation:

$$Na_2O + H_2O = 2\ NaOH$$

These conclusions agree perfectly with the picture that has been made concerning the structure of glass; in this structure there is no room for "free" gaseous molecules. It is equally proper to cite in this field the experiments of Thilo[10]. He indicates various compositions in which water vapor is joined to the silica.

Loeffler[1] also studied these phenomena of dissolution and called attention particularly to the fact that Salmang and Becker[7] found in carbonated glasses twelve times greater volume of water vapor than carbon dioxide, although in the products obtained one finds incomparably more carbon dioxide than water vapor. He demonstrates that silicate of sodium (2:1) absorbs the water avidly and retains it firmly[11]. He concludes from this that the moisture in the batch is retained in its entirety from the time of the first reactions. These reactions were considered above as taking place within the mass of the batch. Later on, when the basic silicate disappears progressively through the dissolution of the sand, the water remains in the solution with a change of the type of bonding or the formation of a supersaturation. Loeffler[12] shows besides that the other basic silicates (and not only the 2:1 silicate) also retain water vapor very strongly.

Further research on this question was done by Weyl, partly with his collaborators Moettig and Thumen[13, 14, 15]. Weyl dissolved carbon dioxide and oxygen under high pressure in molten glass and thus was able to prove that there exist equilibria for the solution of this gas in the glass. Above all, it has been established that, for increasing temperatures, the equilibrium was displaced toward the least amount of carbon dioxide. This phenomenon acts very favorably for fining, for it is precisely at elevated temperatures, preferred for fining, that the tendency toward evolution is strong. The position of this equilibrium for ordinary pressures cannot be deduced from Weyl's experiments.

Dietzel and Cszaki[16] studied the question of equilibria with oxygen, while equilibria with water vapor were studied by Dietzel and Geppert[17] (1935).

In addition, Dalton [18, 19] studied the solubility of gases in glass as Shadduck and VanZee[20] did later. The results of their experiments confirm the discoveries of Salmang and Becker, including those pertaining to the high amounts of water vapor. In the latter work[20], a comparison of the values found for the glass as it came out of the doghouse and the channel (of the feeders) should be mentioned particularly. In the two places, the amounts of gas were found to be practically

equal; in other words, the amount of gas does not change during the entire passage through the tank. An explanation of these important facts has not been found. Even an increase in the amount of H_2O has been observed which the authors attribute to the amount of water vapor in the atmosphere of the furnace. This hypothesis is corroborated by the fact that a glass which contains 0.529 N cm^3/g in an industrial furnace contains only 0.148 N cm^3/g in a laboratory electric furnace.

Salmang and Becker also observed this influence of the furnace atmosphere on the amount of water vapor. Loeffler[1] maintains the view that the water vapor existing in technical glasses comes, as was stated earlier, in a large part from moisture in the raw materials, the water vapor coming from gases of the furnace having only a negligible importance.

The water vapor in a glass melt, according to Loeffler[12], can be detected if sodium chloride is added to the melt. The water vapor from the molten glass is changed by the action of salt into hydrochloric acid which is perceptible to the smell.

The SO_3 content of glass has also been studied in detail during fusion: it is notably the object of the work of Jebsen-Marwedel and Becker[21], which deals with the process of the evolution of SO_3 and the influence of the furnace atmosphere.

The influence of alkalinity on the gas content is shown by Jebsen-Marwedel in another work [22, 4]. He shows that an increasing amount of silica in the glass melt decreases the ability of the glass to dissolve gases. This hypothesis has been confirmed by Reil's[23] observations. He worked with sands of different sizes, and, thus, with varying speeds of melting. A coarse sand melts, in fact, more slowly and can still react during the last stages of melting; it also decreases the amount of SO_3 in the glass.

Jebsen-Marwedel[4] and Loeffler[1] show that the equilibrium between melting and gas evolution in the glass is established very slowly and, in all cases, follows a slower "time table" than that of technical melts. Gas evolution does not follow the "time table" of melting which corresponds to an elevation of temperature. In fact, it is necessary to expect a gaseous supersaturation of the glass. The evolution at the melting temperature can, because of this delay, only produce an equilibrium state corresponding to a lower temperature. This is why all glasses are susceptible of evolving gases again upon reheating.

As proof of a gas supersaturation of the glass melt Loeffler[1] recalls the fact that gas evolution is caused by sprinkling on the glass materials having a rough surface. He establishes a comparison with analogous phenomena which take place with water supersaturated with carbon dioxide. Jebsen-Marwedel[24], Day[25] and others point out that, in experimental melts, fining is often found to be influenced by the ceramic material of which the crucible is made. This produces gas evolution of long duration because of its surface roughness and contrary to what takes place in the tank.

In addition, the investigation of Dietzel[16] on the melting of borates can be considered as analogous proof of supersaturation in molten glass. In molten glass from which the water had been taken, metallic oxides with dissociable oxygen were introduced and the oxygen potentials were measured. Thus, with cerium oxide a very strong gas supersaturation has been found. Loeffler[1] shows, with the aid of special corundum crucibles whether a glass melt is supersaturated with gas or not. As a result of either an effect of points or of capillary action (or of both), the inside surface of corundum is covered with a thick layer of bubbles which is greater with a moist batch and less with the addition of fining agents. Apparently this degassing effect of the corundum is not caused by the dissolution of Al_2O_3 in the glass melt, because inner surfaces of much more soluble porcelain do not produce this evolution or gaseous decomposition. In all cases, the supposition which explains the formation of this layer of bubbles is a gas content in the molten mass which corresponds to one or more atmospheres pressure and, thus, to a supersaturation. The upper edge of the glass melt in the corundum crucible has never been the location of such a formation of bubbles for here, as a result of the diffusion of gases to the exterior of this mass, the supersaturation has disappeared.

In conclusion on this subject, it is proper to point out the investigation of Jebsen-Marwedel and Dinger[26], who have given data on the temperatures at which completely fined glasses could again produce gases. They used drawn samples placed in a furnace in which the temperature fall was 200°C for 15 cm of length. These samples were heated and the furnace was then placed very rapidly under vacuum: a spontaneous evolution of gas was thus produced. The samples showed, clearly, a temperature limit for gas evolution; for various kinds of glasses the degree of fining was well established. The observations made are very interesting because of the well known tendency of glass and, in particular of sulfate glass, toward a new evolution at the time of reheating (the formation of little, delayed bubbles).

The gaseous equilibria which are established in a glass melt correspond, in general, to a temperature situated well below the maximum temperature to which the melt has been brought. If a new formation of bubbles is to be avoided when fusion is prolonged, it is necessary to remain at least 100°C below the maximum temperature previously attained. The actual equilibrium probably corresponds to a still lower temperature.

2. Formation of Bubbles

A whole series of phenomena simultaneously influence the evolution of gases: the thermal decomposition of raw materials, the thermal dissociation of the compounds which remain in the batch during fusion or which form there momentarily, the reactions of the silica and the atmosphere of the furnace with the compounds containing gases which are found in the glass batch, the reactions among themselves of the compounds containing gas and, finally, the expulsion of the bubbles and their appearance at the surface of the bath. The approach to equilibrium is extremely slow and sluggish because of the fundamental tendency of glass to slowness. As long as one deals with the thermal dissociation of isolated raw materials, the situation is simple. The decomposition temperatures are known.

Jebsen-Marwedel[4, 24] points out that the decomposition temperatures can be displaced slightly as a function of the amount of carbon dioxide in the furnace atmosphere. Thus it is that $CaCO_3$ in an atmosphere coming from the combustion of producer gas (16 per cent CO_2),

begins to decompose at 760°C while with the atmosphere coming from the combustion of coke gas (8 per cent CO_2), the corresponding temperature is near 710°C. In the interior of a lump of unmelted batch (according to Jebsen, an atmosphere of almost pure CO_2) the decomposition begins at about 910°C.

He insists also on the fact that many other factors play a role, for example, the shape and surface of the batch mixture put into the furnace. In the interior of the lump a very high partial pressure of carbon dioxide must be expected; the area of the reacting batch and the formation of layers affects the decomposition.

The situation is much more complex when the gases must be liberated from the molten glass. Dietzel[3] maintains "that the formation of a bubble requires the creation of new surfaces in the interior of the glass". That means that the structure of the glass is broken and opened over a large surface (from the atomic point of view); that is, a large number of Si-O-Si bonds are broken at the same time. These bonds, although already a little loosened by the currents in the glass melt caused by variations in temperatures are, however, relatively strong, and a large quantity of energy is necessary to simultaneously break a large number of them. (Viscous flow arises, however, from the continued breaking and making of individual bonds.)

Smekal[27] has evaluated the molecular resistance to rupture at ordinary temperatures as 1000 kg/mm, or 100,000 atm; this number, or at the very least its order of magnitude, is probable also for higher temperatures. That would mean then that a gas which is released is normally not soluble in the glass, but must remain dissolved during fusion until: (1) it comes out of the glass by way of diffusion, or (2) as a result of the progressive destruction of the fining agent, the gas pressure is raised to a point where it can destroy the structure of the glass and thus form a new internal surface, that is, a bubble. The theory requires the enormous pressures mentioned above.

These considerations are confined by the investigation of Csaki and Dietzel[16] of the oxygen pressure in the glass during fusion, permitting one to arrive at a similar order of magnitude by a prudent extrapolation.

If the question of gas release is studied from another viewpoint, that is, if research is done on the pressure that must prevail in a bubble of a determined diameter[39], it is found that it depends on the atmospheric pressure at the surface of the melt, on the pressure exerted by the column of molten glass, and, finally, on the surface tension of the bubble. For this latter tension, the formula: $p = \frac{2\sigma}{r}$ can be used, in which p is the pressure in the bubble, σ the surface tension, and r the radius. For a surface tension of 300 dyne/cm the pressure in a bubble of 1/1000 mm diameter is 6 atm. For large bubbles of 0.1 mm and more the influence of the surface tension can be ignored, but for the very little bubbles this influence plays an important role and broadly surpasses that of the hydrostatic pressure. As the diameter approaches zero, the pressure increases indefinitely. Therefore, for very small dimensions, very high pressures can be expected.

Loeffler[1] admits, it is true, that for thermal dissociation, water pressures other than those given by Dietzel can suffice (see above). Each time a bubble is formed in liquids, a rupture of the structure must be produced. This is not a property peculiar to the network of the silicates. The gas supersaturation of water can be much greater than that of a glass melt although, in the case of water, the work of separating the molecules is probably less than in the case of silica.

All of these considerations concern the release of gas from a homogeneous glass melt. But, in addition, heterogeneities (striae) must be considered as a cause of bubble formation. These phenomena have been described and explained principally by Jebsen-Marwedel[24, 29]. When, for example, a reduced glass containing sulphur meets a stream of glass containing sulphates, SO_2 can be formed.

When a layer of acid glass comes in contact with another containing carbonates, it is equally possible to have a production of bubbles there.

Jebsen-Marwedel describes next the role of refractory materials on the formation of bubbles. He states that alumina from blocks dissolved in the glass, the same as for other acids and especially SiO_2, diminishes the dissolving capacity of the glass with respect to gases and thus causes bubbles. This phenomenon can be produced as well for glass rich in alumina in contact with refractory materials as for striated glass which, by its lifting power and the action of the currents, has been driven from its original position into the mass of glass.

The hypothesis generally given for explaining these phenomena is the gas supersaturation in the body of the molten glass.

As other sources of bubbles, Jebsen-Marwedel has pointed out the quantities of air trapped in the pores of the refractory materials, and also the impurities of these refractories. For example, pyrite leads to an intense production of bubbles when it comes in contact with the glass.

It is possible that the refractory materials, as a result of reduced firing, retain carbon which, ultimately, liberates sulphurous gases by the reducing action on the sulphate, for example.

These phenomena and their consequences, that is, bubbles in the glass, do not necessarily belong exclusively to the question of fining for they can come out at any place whatever in the furnace, such as in the working compartment. However, fining means, strictly speaking—besides the homogeneity—the elimination of gases and bubbles coming from the glass melt.

The particularly large proportion of SO_3 in the gases retained in glass makes it necessary to pay particular attention to this gas. This question will be taken up at the time of the discussion concerning fining agents, for Na_2SO_4 is very often used as such.

4. Ascension, Growth and Bursting of Bubbles

According to earlier concepts of the behavior of fining, the fining agent produced large bubbles, which when rising in the glass melt, either dragged along in their movement the smaller bubbles which they ran into, or combined with numerous little bubbles, so that finally a glass remained as free of big bubbles as of little bubbles. This conception is no longer valid today. The joining of several bubbles has been effectively observed and

described by Jebsen-Marwedel[4]: moreover it is not rare but it cannot in any case be considered as the main point of the phenomenon of fining. The extraction of the gases contained in the glass melt is incomparably more important. It must be stated that toward each individual bubble during its trip through the glass melt, new quantities of gas flow by diffusion from neighboring layers. Therefore, in the region of the path crossed by a bubble, there is a decrease in the gas content. When the gas content of a glass melt is greatly decreased in this way, as is actually the case, there must be then, as Dietzel[3] points out, a large number of bubbles of small diameter, because diffusion can take place only over a small distance in the amount of time available. How slowly this diffusion takes place can be seen, knowing that the coefficient of diffusion for glasses is 0.01 to 0.1 $cm^2/24$ h (Widtmann[30]), even though it is usually in the order of $cm^2/24$ h in liquids and cm^2/sec in gases. The coefficient of diffusion is proportional to the radius of the diffusing molecules which explains the established differences.

These facts confirm the preceding consideration according to which a very large number of bubbles are necessary for gas release from a glass melt, in order that the diffusion paths need only to be short.

The rate of bubble rise is given as Jebsen-Marwedel[24, 25] indicates by Stokes' formula:

$$v = \frac{2.r^2.g.\ d_1\text{-}d}{9 \qquad \mu}$$

in which v is the rising speed sought. It is determined by $(d_1\text{-}d)$, the difference in the densities of the gas, the acceleration due to the weight g, the viscosity of the glass μ and the radius of the bubble r.

Considerations based on hydrodynamics show that, in the boundaries of the magnitudes studied, only laminar flow takes place and that the Reynolds numbers which arise here are very small. With bubbles of a diameter up to 20 mm and beyond, and with viscosities of 10 poises and more, R always remains lower than 1: therefore, effectively, there is only laminar flow. For these values, Stokes' law is applicable.

It is known that the differences actually existing in the bubble diameters and in the viscosity values have a considerable influence on the rising speed of the bubbles. The difference between the densities of most gases and that of glass is in practice the same, so that this factor can be considered as being approximately a constant as long as there does not exist any inclusions of sulphate droplets (salt bubbles) which can be in equilibrium in the glass. The radius of the bubble, which is squared in the calculation, is, as one must expect, of fundamental importance; the big bubbles rise more quickly than the little ones. It is known that it is very difficult to eliminate the little bubbles from the glass melt. In addition, the role of the viscosity must not be under-estimated, although it enters only in the first power. In the melting range, an elevation of temperature of about 200°C is sufficient to render the viscosity ten times smaller. From this it can be understood why it is necessary to maintain the glass as hot as possible in the fining range in order to facilitate the rising of bubbles in the glass. Occasionally, the addition of certain products to the batch is used in order to lower the viscosity of the glass and thus improve the fining. Among these products calcium fluoride can be cited.

Taking the preceding relations as a basis, one can calculate that a lead glass, as a result of its low viscosity, allows a more rapid evolution of the fining bubbles than a soda-lime glass: in other words, a smaller bubble diameter is sufficient for eliminating the bubbles in a given time.

Similarly, it can be calculated that bubbles of a size corresponding to about 1 mm in diameter can come out of a soda-lime glass of normal viscosity at temperatures between 1250 and 1400°C with a rising speed from 0.6 to 6 mm/mn. Such a bubble takes from 800 to 80 minutes to rise from a depth of 50 cm on, the highest number corresponding to the highest viscosity, that is to low temperatures. It is thus seen, by these rough evaluations, that inadmissible lengths of time are required for the little bubbles. With pot furnaces, 3 to 4 hours are used for fining and with tanks the interval is still shorter. It must be noted, finally, that the rising speed of bubbles can be radically modified by the vertical components of the currents in the glass. The surface glass is displaced in the fining compartment of the tanks at speeds of from 1 to 5 m/h. In other words, it goes through the space reserved for fining in a time varying from ½ hour to 2 hours. Actually, the speed of the glass currents decreases with depth; it is cancelled in the tank, according to present theories on flow, at a depth between 40 and 60 cm, and, on an average, it can be said that the time available for fining in tanks is no greater than for pots.

The relationship between the diameter of the bubbles, the temperature of the glass and the rising speed of the bubbles has been presented by Jebsen-Marwedel[24] for a soda-lime glass in the form of a three-dimensional diagram. The same relations have been presented elsewhere[22] by a simple plane diagram. Unfortunately, very little is known about the influence of the nature, the quantity and the coarseness, etc., of the different fining agents on the diameter and number of bubbles. The dosage of these agents depends either on empirical data or on laboratory experiments which had as an object, principally, the study of the final stage of fining.

As a result of the diffusion of the gases dissolved in the glass, the diameter of the bubbles increases and, consequently, so does their rising speed. Without this diffusion, it can be calculated that the diameter of the bubbles would remain almost constant during the total rising path. Thus, as the quantity of gas increases the diameter, the rising speed increases and, at the same time, by reason of the decreasing surface tension, the diffusion of other quantities of gas is facilitated. It is in all cases desirable that bubbles of about 1 to 2 mm diameter form. However, the conditions for obtaining them are not known adequately.

A particularly complex question is that of the bursting of bubbles which have reached the surface of the glass melt and are separated from the furnace atmosphere only by a fine film of glass. The interior pressure of the bubble and the surface tension of the glass play a decisive role here. To the extent that surface tension is observable, it is influenced principally by the composition of the glass and to a slight degree by the temperature. In soda-lime glasses the surface tension varies only

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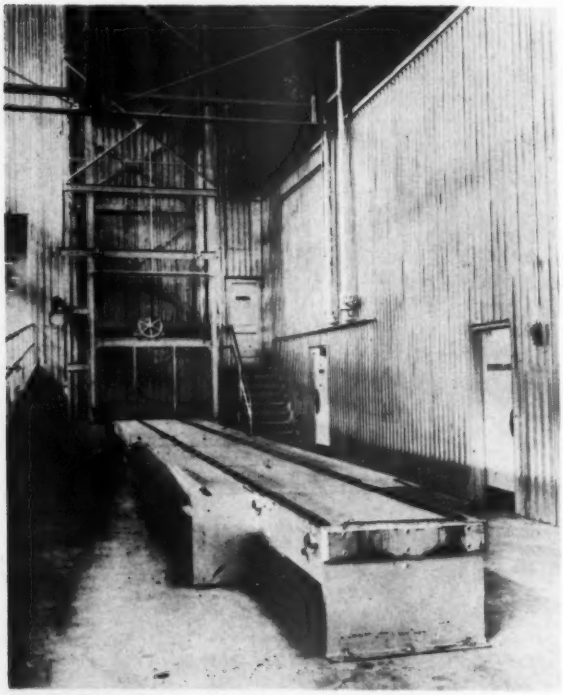
Brockway Integrates Carton Materials Conveying and Production at Freehold

• A WEEK'S REQUIREMENTS for packaging and carton-making materials are automatically transferred from first-floor receiving area to second-floor storage in an hour and a half at Brockway Glass Company's new plant in Freehold, N. J.

The transfer operation is centered around an automatic interfloor conveyor which was designed, engineered (in coordination with Brockway) and installed by Gifford-Wood Co., Hudson, N. Y. The push-button conveyor moves loaded pallets down a 47-ft. conveyor to a vertical transfer unit, which carries them up to a second-floor receiving conveyor, adjacent to the plant's storage area. All elements of the system are interlocked to provide a completely automatic transfer. And four pallets can be accommodated on various elements of the system at the same time.

The G-W conveyor was considered an essential element of Brockway's overall materials handling system when the plant was under construction last year. Its function is to insure that a supply of carton-making materials, including fillers, partitions, liners and the cartons themselves, is always on hand for orders that the company is processing. Since a great variety of glass containers is manufactured at the plant, and carton materials of various sizes are ordered from suppliers as required, the supply problem is an intricate one, with a materials handling system requiring a combination of speed, adaptability to a wide range of loads, and economy of space and manpower.

Fork truck operator positions pallet load of packaging materials on the conveyor. As soon as this load has moved past the initial loading conveyor of the system, another pallet can be started on the interfloor transfer sequence.



Lower level showing the three-section horizontal conveyor and a portion of the vertical conveyor. Gig is in down position behind safety screen. The horizontal conveyor was extended beyond inclined ramp (at left) and office areas (right) to facilitate loading operations.

Brockway's manufacture ranges from pharmaceutical containers to bottles for soft drinks and includes bottles for the food industry (citrus fruits, ketchup), soft drinks, nursing bottles and bottles for alcoholic beverages.

Since all carton-making and bottle-packaging operations are coordinated with actual bottle-making into one continuous production operation, the efficient handling of carton materials is a vital factor in the overall production picture.

Brockway handles its packaging problems as an adjunct to its main bottling manufacture, rather than as a separate program. When an order is received from a customer for a certain quantity of bottles, this order is scheduled for manufacture. At the same time, Brockway contacts one of its carton suppliers, ordering all necessary cartons and components to the dimensions required by the particular bottle produced. Shipment of the carton materials is then coordinated to coincide with the bottle

manufacturing process, so that the normal storage time for carton materials is at most a matter of a few days, before the materials move through fabrication and packaging lines.

In this way Brockway minimizes its inventory problems on packaging materials, which would be tremendous if a large permanent inventory were attempted. However, such a system requires extremely close coordination—and a fast, fool-proof materials handling system for incoming shipments.

Shipments of carton materials are delivered by van to Brockway's receiving area, in its main warehouse. Shipments are either received on 40 inch by 48 inch pallets, or loaded on this size pallet after receipt. They are then moved by fork truck to the G-W interfloor conveyor, for transfer to the second floor storage area. This area is immediately adjacent to plant's carton-making line.

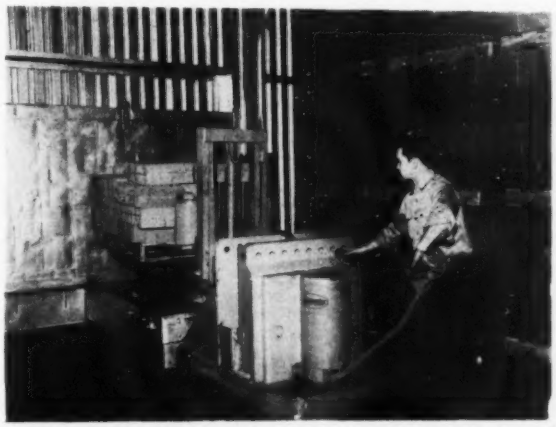
Several features of the G-W conveyor are important to the success of this phase of Brockway's operation:

Speed: a complete trip, from load to unload stations, takes slightly over 1½ minutes. However, the transfer rate is much higher than this when the system is in full operation. Four pallets can move through various elements of the system at the same time—one on each of three horizontal conveyors on the first floor, one in the gig. In effect, this means that loads can move through the system almost as fast as operators at either end can load and unload pallets into the system. Two truck trailer loads of material, equivalent to a week's packaging requirements, can be transferred and stored in 1½ hours.

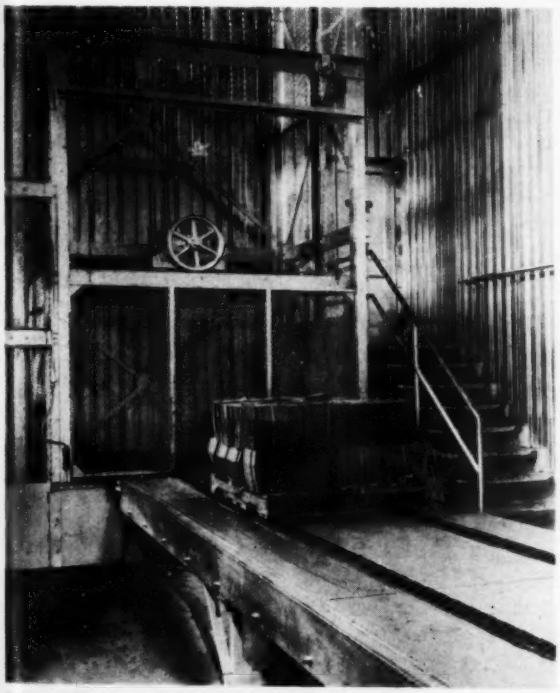
Versatility: the conveyor is a two-way system, to permit the return of empty pallets from the second to the first floor after they have been unloaded. The complete system can be reversed from either of two push-button stations, located near load and unload points, simply by turning an indicator knob. This reverses all electrical and conveying elements, through the system's main wiring panel. Direction of conveying, forward or backward, is indicated by red and green signal lights at each floor.

Special design features: at present all five horizontal conveyors (3 first-floor, 1 gig, 1 second-floor) consist of two powered parallel operating-type chains, with a continuous sheet metal surface between. Chain centers are 2 feet 8 inches apart, to accommodate the 40 inch by 48 inch pallets Brockway is currently using.

However, the company anticipates changing over to a larger 72 inch by 48 inch pallet in the future, to increase its transfer capacities. This changeover was discussed with Gifford-Wood when the system was under discussion, and provisions made to anticipate it. Each conveyor frame contains channels for two additional chains, which can provide the company with a maximum conveyor width of over 5½ ft. All motor and electrical components are rated to accommodate this larger load, as well as current load requirements.



Pallet is unloaded from short receiving conveyor at second floor of system. Operator then transfers load to adjacent storage area, at right. Gig that delivered load has already moved downstairs for another load.



The pallet travels to the vertical conveyor at a speed of 45 FPM. Action of the safety screen is interlocked with the horizontal conveyor so screen will automatically open as pallet moves into loading position.

The length of the first floor conveyor represents another instance of advanced planning. For most of its length the conveyor runs between a series of offices and an inclined ramp. It was designed to extend beyond these obstructions into a clear area, 47 ft. from the vertical conveyor. This layout locates the load-unload operation in an area where fork trucks are able to maneuver loads easily onto the conveyor.

Before starting a transfer sequence, the operator checks the panel lights to see which direction the conveyor is set to travel and makes sure the gig is in a receiving position. Following initial sequence, the gig will automatically return to load station for successive loads.

In an UP transfer operation, the following sequence occurs:

1. Operator places loaded pallet on short section of lower horizontal conveyor. He then presses the START button, suspended from the ceiling so he can reach it from his truck.

2. Pallet then moves down the 47-ft. conveyor at a

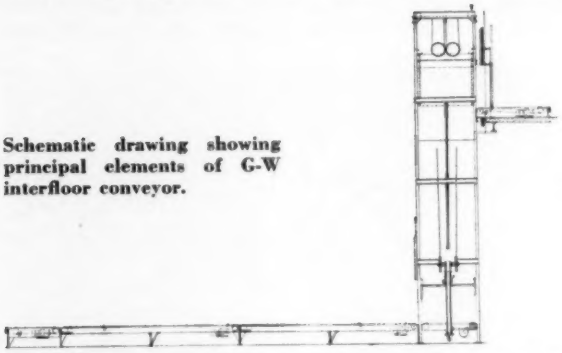
speed of 45 fpm.

3. As pallet approaches gig, it contacts a switch which actuates the opening of a well door in front of the gig entrance. Pallet moves onto floor conveyor in the gig. At the rear of the gig, pallet strikes another switch which stops this conveyor and closes the well door. Closing of door actuates a switch which starts gig motor. Gig rises at a speed of 70 fpm.

4. As the gig approaches the second floor, it contacts a switch which cuts off hoist motor and starts a smaller leveling motor. Gig is leveled with second floor at 5 fpm.

5. Leveling action contacts switch, which opens second floor well door. This in turn starts both the conveyor inside the gig and the second floor receiving conveyor.

6. Pallet moves out of gig onto receiving conveyor, where it trips a limit switch. Both conveyors stop, well door closes and gig returns to first floor for another load.



Schematic drawing showing principal elements of G-W interfloor conveyor.

During this sequence, the first floor operator may load three more pallets into the system. The first will travel the length of the first floor conveyor, then stop before the well door until the gig returns to that level. The second pallet will be held on the middle section of the long conveyor, again through the action of a limit switch, and the third pallet will be held at the short load conveyor. Each of these loads will be automatically indexed each time the vertical conveyor completes another trip between floors.

The downward transfer sequence, for returning empty pallets, is the same as upward movement, except that no indexing provisions are included.

All wiring for the complete system is controlled from a single panel located on the second floor. It contains all necessary motor starters, reversing switches, relays and contacts. Other controls include well limit switches, door travel limit switches, gig limit switch and safety switches for the main hoist, leveling device and all cables.

• Promotion of D. J. Brett, Jr., to personnel manager for the Mill Division of Owens-Illinois Glass Co. has been announced by C. G. McLaren, vice president and general manager of mills and woodlands.

Mr. Brett has been personnel manager of the company's paper mill at Valdosta, Ga., for the past year. He is being succeeded in that post by Foster Coleman, personnel manager of O-I's glass container plant at Waco, Tex.

• Joseph Barnett, Jr., has been assigned to the general industrial engineering department of the L.O.F. Glass Fibers Company as a junior industrial engineer.

FOAMGLASS INSULATES MINE CONVEYOR TUBE

Because of extreme weather conditions (temperatures have reached as low as –50°F in winter) Steep Rock Iron Mines Ltd. have made plans for both surface and sub-surface mining at their new Atikokan, Ontario mine.

During the winter, a conveyor belt carries the ore from far below the surface to a "tipple" above ground. From the point where it emerges from the ground to the "tipple", the belt is enclosed in an 8 ft. diameter steel tube.

A serious problem arose, however, due to the wet condition of the ore and the severe outside temperatures. Moisture condensed on the cold surface of the tube, building up heavy frost layers over six inches thick. This seriously interfered with the operation of the conveyor.

At the outset, the tube was heated from within by a steam pipe and covered with an insulation. This in turn had a weatherproof coating. However, the combination of severe moisture problem within the tube and extreme outside weather conditions, caused this insulation to fail.

It was decided to reinsulate the tube, this time on the inside, using an insulation that would be unaffected by moisture. Foamglas insulation, a product of the Pittsburgh Corning Corporation, was chosen. Its composition of sealed glass cells makes it impervious to vapor and moisture. In addition, its ultimate compressive strength of over seven tons per sq. ft. enabled the company to pour a concrete wearing floor for the lower portion of the tube directly over the insulation.

A 60-ft. long tube was first insulated and placed in use during the winter of 1954-55. It proved so successful that a second 260 ft. long tube has now been insulated and placed in service. Other similar applications are under consideration.

To insulate the top half of the tube, pins were stud welded to the inner surface which was then primed with an asphalt primer. A layer of one and a half inch thick Foamglas was next applied with hot asphalt. The Foamglas blocks were also impaled on the pins and secured with spring clips. Another layer of one and a half inch Foamglas was then applied using hot asphalt as the adhesive. A final finish of mastic was then troweled on. On the bottom of the tube, the cellular glass insulation was mopped on with hot asphalt and concrete poured directly over it.

Insulation contractor was Lakehead Insulation & Suppliers Ltd. of Port Arthur, Ontario.

TOLEDO AWARD REPLICA DEEDED TO TOLEDO MUSEUM

The Northwestern Ohio Section of the American Ceramic Society has recently deeded a replica of the engraved glass vase representing the Toledo Glass and Ceramic Award to the Toledo Museum of Art. Ralph K. Day, as chairman of the Section, presented the vase to Blake-More Godwin, museum director.

The model vase was made by the U.S. Glass Company, designed by Edwin C. Fuerst and engraved by Duke Greiner. It has been on display in the Museum's renowned glass collection for more than a year and is now a permanent acquisition.

Glass-Making Raw Materials of California

Their Influence on Glass Technology, Furnace and Machine Operation

By W. A. SEITZ, Glass Containers Corporation,
Antioch, California

Introduction

• A FEW YEARS AGO, a glass technologist from the Middle West visited Southern California. During his stay he attended a meeting of the local glass section. He expressed his amazement at what seemed to him to be an unusually large attendance. The presence of over seventy glass men, he later learned, was not the exception but rather the rule, for within a radius of 25 miles of the meeting place are located six large container factories and one flat glass factory.

It is obvious that such a concentration of glass factories has created a special situation in regard to raw materials. An attempt will be made in this paper to illustrate how the requirements for sand, limestone and soda ash have dictated a new and different aproach as to source and type of raw material. A further attempt will be made to show how the different types of material native to and employed in California have changed some basic concepts of glass technology, furnace, and machine operation.

Glass Industry in General

The best method of illustrating the size and concentration of California's glass industry is the study of a map, Fig. 1.

The glass factories are concentrated in two areas: One in Northern California, on the east side of San Francisco Bay, and the other in Southern California, with a majority of the plants being located in the southeast section of Los Angeles.

In Northern California, there are four container factories, all of which are within a twenty-mile radius. The construction of a fifth plant has been announced.

The four existing plants operate ten furnaces with a total daily capacity of more than 1200 tons of glass. Production is predominantly flint glass with some amber and light green also produced. In addition, there is a fibre glass plant operating in Santa Clara.

Eight glass container plants and one flat glass plant are in operation in Southern California. These factories, with the exception of the Saugus and Pomona facilities, are again concentrated in a relatively small area. Sixteen furnaces melt 1500 tons of glass per day. Production in this locality also, is mainly flint with some amber and green used.

The enormous increase of California's population in the postwar years has been responsible for the expansion and present size of the glass industry. This growth has not only taxed existing raw material supplies, but has also dictated the development of new sand sources. It might be of interest to trace this development over the years.

Up to the late thirties, most of the silica sand used in California was Belgium sand. It was carried as ballast on ships bound for ports on the West Coast. Strikes, tariffs, and threatening war clouds necessitated more reliable sources of glass sand for the industry. During this period the first attempts were made to develop the local feldspathic sands near Corona and Oceanside in Southern California, and Brentwood in Northern California. The beach sand deposits near Del Monte also attracted the attention of the glass industry.

The largest potential of a satisfactory sand appeared in the silica deposits on the northeastern corner of Lake Mead in Nevada. The deposits were extensive in nature and close to a major railroad for transportation to the glass center of the West Coast. Over the years elaborate sand processing plants were constructed which supplied the glass sands during the war and postwar periods.

The deposits are high silica deposits (99+ per cent S_1O_2) which contain lenses and striae of quartz so heavily stained with iron oxide as to give the sand a red appearance. Although the beneficiation plants accomplished an outstanding job in the removal of heavy minerals and ferroginous clay, the iron-stained grains were im-

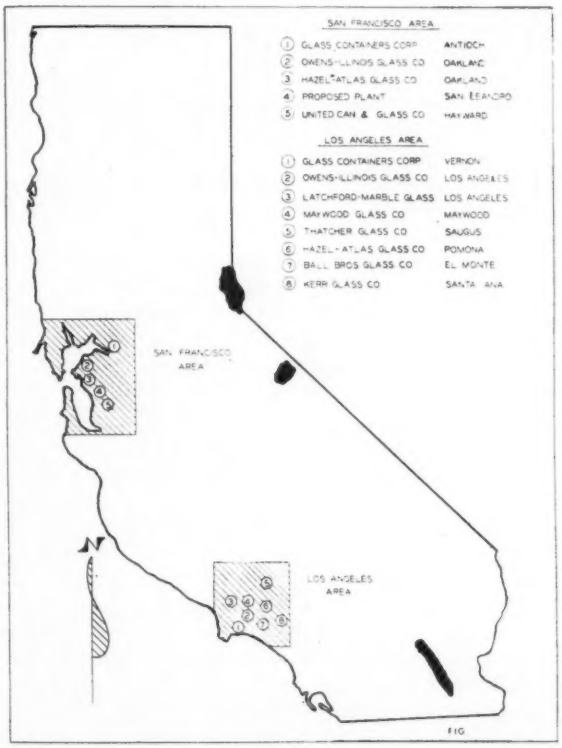

SAN FRANCISCO AREA
1 GLASS CONTAINERS CORP ANTIOCH
2 OWENS-ILLINOIS GLASS CO OAKLAND
3 HAZEL-ATLAS GLASS CO OAKLAND
4 PROPOSED PLANT SAN LEANDRO
5 UNITED CAN & GLASS CO HAYWARD
LOS ANGELES AREA
1 GLASS CONTAINERS CORP VERNON
2 OWENS-ILLINOIS GLASS CO LOS ANGELES
3 LATCHFORD-MARBLE GLASS LOS ANGELES
4 MAYWOOD GLASS CO MAYWOOD
5 THATCHER GLASS CO SAUGUS
6 HAZEL-ATLAS GLASS CO POMONA
7 BALL BROS GLASS CO EL MONTE
8 KERR GLASS CO SANTA ANA
SAN FRANCISCO AREA
LOS ANGELES AREA
N
FIG

Fig. 1

Presented at the Seventeenth Conference on Glass Problems, The Ohio State University, Columbus, Ohio, December 6 and 7, 1956.

possible to remove. The iron content of the Nevada sand was consequently a variable, and posed a constant problem in the decolorization of flint glass.

The continued increase in freight rates experienced in the last few years, coupled with the rising costs in the processing plants, changed the sand from a low-cost to a high-cost raw material. This provided the impetus for the development and use of local feldspathic sand deposits.

During this period facilities were also enlarged to increase the production of soda ash and limestone.

Raw Materials in General

The locations of the glass-making raw materials and their distance from the manufacturing centers are illustrated in Fig. 2. The materials available in Northern California are:

1. Sands:
   a. Ione Sand: High silica sand with exceptionally low iron content.
   b. Del Monte I.F. Sand: A feldspathic sand with an alumina content of approximately 11.5 per cent.
   c. Pacific Clay, Camanche Sand: A feldspathic sand with an alumina content of 4.0 per cent. The processing plant was put in operation early this year.
2. Feldspar: Del Monte No. 99 spar, processed from the Del Monte beach sands.
3. Limestone: Calcite limestone from deposits near Sonora and El Dorado.
4. Soda Ash: Processed from the brine of Searles Lake in the Mojave Desert and the underground deposits of Green River, Wyoming.

The materials available to the Southern California factories are:

1. Sands:
   a. Nevada Sand: High silica.
   b. Corona Sand: A feldspathic sand with an alumina content of 4.0 per cent and iron content of .035 per cent.
   c. Oceanside Sand: A feldspathic sand with an alumina content of 5.0 per cent to 6.5 per cent.
2. Feldspar: Del Monte feldspar No. 99.
3. Limestone: A calcite limestone from deposits near Colton.
4. Soda Ash: From the brine of Searles Lake in the Mojave Desert.

Soda Ash

The bulk of the soda ash used is processed from the brines of Searles Lake in the Mojave Desert. A complete coverage of the geology, mineralogy, and formation of this deposit is beyond the scope of this paper. However, the romance connected with the origin and early discovery of this vast stock pile of chemicals demands a few words.

Eons of years ago, according to geologists, the lake was formed by many glacial streams which originated in the High Sierras north of the desert. As the waters of these streams passed over the rocks in the mountains and valleys, minerals were leached out and carried to the lake. With a warmer climate the icecaps disappeared and the flow of water subsided. Periods of higher temperatures with decreased rainfalls followed, resulting in evaporation of the lake. Over the ages the drying up of the lake continued. Saturation and crystallization points were reached which left a mineral crust on the lake up to 135 feet deep. Today, Searles Lake is a porous crystalline mass with approximately 40 per cent voids which are filled with dense alkaline brine. This brine furnishes the mineral salts from which soda ash, borax, saltcake and all of the other chemicals are made.

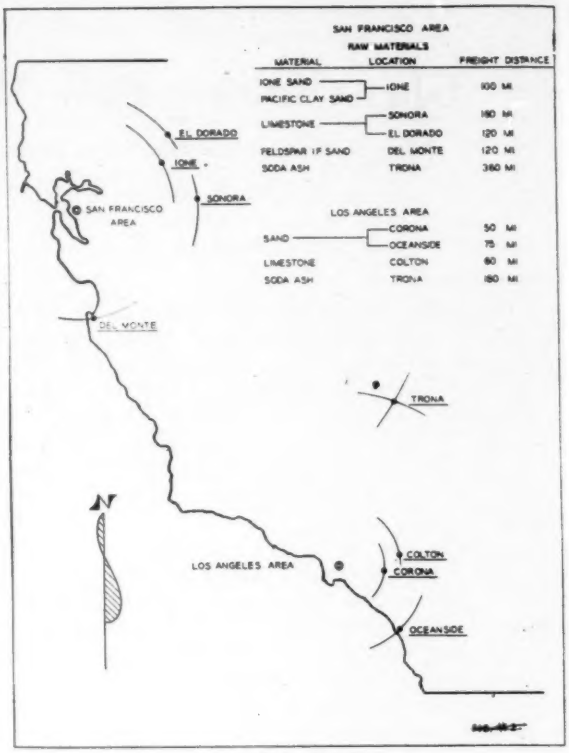


Fig. 2

The lake was discovered in 1862 by a prospector named John W. Searles who staked out several claims on the salt bed. In his quest for gold he discovered the most fabulous deposit of diversified chemicals known in the world today. Although he built a small plant to extract borax, he was not destined to see the chemical empire which was developed by a skillful combination of research and engineering.

A number of companies produce soda ash from the brine with American Potash and Chemical Company and West End Chemical Company furnishing most of the soda ash for the glass industry. Although there exist minor differences in the processes, for the purpose of this paper, a general description should be permissable.

The liquor or brine pumped from several levels of the lake contains more than one-third of its weight in dissolved salts. The chemical composition differs in the various levels. An approximate analysis of the brine from the upper level is as follows:

	Per Cent by Weight
Sodium Chloride	16.2
Sodium Sulfate	6.8
Potassium Chlorate	4.9
Sodium Carbonate	4.7

Sodium Tetra Borate	3.0
Bromine, Lithium, Iodine, etc.	.3
Water	64.1

The process to recover the many chemicals from the brine is basically one of evaporation followed by fractional crystallization. Initially the brine serves as a coolant and, at the same time, picks up heat for processing. Mixed with end liquors from various cycles of the operation, the brine is evaporated under vacuum. Sodium chloride, sodium carbonate, and burkeite, which is a double salt of sodium sulfate and sodium carbonate, are separated from the boiling liquid, and are further processed.

Burkeite is converted into two intermediate compounds: Glaubers salt and sal soda. Glaubers salt, a hydrated form of sodium sulfate, is dehydrated and processed to salt cake. Sal soda ($Na_2CO3.1OH2O$) is concentrated in evaporators, recrystallized as the mono hydrate, filtered, and then dried to produce soda ash.

Deep-level brine with a higher sodium carbonate content is carbonated with CO_2 in two steps to produce the bicarbonate of soda. The bicarbonate is dried, calcined, bleached, recrystallized as the monohydrate and dried to soda ash. It should be mentioned that the CO_2 used for the carbonation comes from waste gases of the boilers and the calcining of the bicarbonate and limestone which is mined in nearby deposits.

Two types of soda ash are available, namely:

	No. 1	No. 2
Na2 B4 07	1.16 per cent	. . per cent
Na CL	0.38	.09
Na2 SO4	0.96	.06
Na_2O	57.39	58.40
Density	49.2	. .
Screen Analysis		
+ 100 Mesh	83.6 per cent	94 per cent
+ 150 Mesh	98.6	98
+ 200 Mesh	99.8	100
— 200 Mesh	0.2	

Glass Sands

Generally when sands are discussed in connection with the glass industry, reference is made to sands with a high silica content of more than 99 per cent. On the West Coast, there is another form of sand, the so-called feldspath sand. The difference between high silica sand and the feldspathic sands is the feldspar content of the latter. Feldspathic sands are composed of two distinct and different grains, these being quartz grains and feldspar grains in varying proportions.

Typical examples of feldspathic sands are:

a. Del Monte beach sands.
b. Pacific Clay Company Camanche sand.
c. Corona sand.
d. Oceanside sand.

Del Monte Beach Sands

One of the first developments of local sand source was the beneficiation of the beach sands near Del Monte, California. The sand is harvested from large wind-swept dunes which are in some places 300 feet higher than the adjacent Pacific Ocean. The origin of this sand is jurassic granite eroded over the ages by the incessant action of the ocean waves. The sand is a mixture of quartz, feldspar and heavy minerals. The grain size is very uniform with all but a trace minus No. 20 mesh and approximately 2 per cent minus 100 mesh. The Fe_2O_3 content in the raw sand ranges from 0.12 per cent to 0.18 per cent with an average alumina content of 11.5 per cent.

In 1951 the construction of a new sand beneficiation plant was started in Pacific Grove. Methods were used to remove all heavy minerals and to permit the separation of quartz from feldspar.

It is claimed that the first successful application of the flotation principle in sand beneficiation was used in this plant. See Fig 3. The raw dune sand is scrubbed at 75 per cent solids in specially designed attrition scrubbers to remove surface stains, clays and organic matter. The scrubbed sand is diluted to 25 per cent solids, screened, thoroughly deslimed, and washed. Successful flotation hinges on clean grains and also on correct Ph control. The minerals in the slime will counteract the conditioning agents unless removed in the washing.

The clean sand is then conditioned at 80 per cent solids for the iron float. Flotation agents added at this stage include sulfuric acid, fuel oil, pine oil, and American Cyanamid reagents of the 800 series. The Ph of 2.5 is important and has to be maintained. The conditioned sand is reduced to 25 per cent solids and is passed through a series of flotation cells, which are air-operated. The froth contains the heavy minerals which are flumed to waste. The tailings or sand is dewatered, dried and marketed as I.F. sand.

Part of the tailings is washed to remove all traces of previous flotation agents, then dewatered and conditioned at 50 per cent solids. Flotation reagents for the second stage consist of hydrofluoric acid, Armac "T" amine, kerosene, and pine oil. The pulp is diluted to 25 per cent solids and floated at a Ph of 2.8. Ph control is again critical. Hydrofluoric acid acts as both Ph control and depressant for quartz. The froth in this float is the feldspar and the quartz the tailing. After the final steps of dewatering and drying, the two products are ready for marketing.

The plant was designed to allow for flexibility in the operation, particularly in the feldspar float. Special sands were produced with variable alumina contents. As will be shown below, the intermediate products were successfully used to produce glass. See Table I.

The feldspathic products processed from the Del Monte sand dunes were and still are the source of alumina for much West Coast glass. The I.F. sand and the intermediate product No. 66 were used on a 100 per cent basis. However, over the years it became apparent that the depletion of the sand dunes and the acceptance of the products in other industries would eventually create shortages. Consequently, the development of other local sources was necessary.

Two major developments ensued:

1. The Owens-Illinois Glass Company plant in Ione.
2. The Pacific Clay Company palnt in Camanche.

The two sand processing plants represent massive developments utilizing the latest equipment available in flotation and sand beneficiation. The operations are located on the Ione formation, an important source of

Table I

Typical Analysis

	No. I.F.	No. 66	Feldspar No. 99
Silicon Dioxide	81.9 per cent	86.06 per cent	68.0 per cent
Iron Oxide	.081	.059	0.101
Aluminum Oxide	11.10	8.20	18.90
Titanium Dioxide	Trace	....	.008
Calcium Oxide	0.72	1.26	2.52
Sodium Oxide	3.08	2.27	5.36
Potassium Oxide	2.45	1.78	4.39
Loss on Ignition	.55	.60	.68
Screen Analysis			
+ 30 Mesh			1.0 per cent
+ 40 Mesh	14.8	14.1	11.7
+ 60 Mesh	72.0	76.1	68.8
+ 80 Mesh	12.6	9.4	17.6
+100 Mesh	.5	.3	.6
+140 Mesh	.1	.1	.2

non-metallic minerals in California. It extends over a length of 200 miles and is six miles wide. This formation, which has been divided into upper and lower levels, is, for the most part, a mixture of white clays and sands.

Although the lower level is in general a mixture of clay mixed in varying proportions with quartz sand, there are lenses and layers composed entirely of clay. The mixture of sand and clay varies from a small percentage to as high as 60 per cent sand. There are also some beds which are 100 per cent quartz sand. The upper level of the formation contains mostly clays, with some clay and sand mixtures. The sands in the mixtures are feldspathic sands. The sand grains were formed by weathering from crystalline rocks of hte Sierra Nevada. The sharpness of the grains and the marked degree of angularity indicate that their source rocks were within 30 to 40 miles away. Orthoclase feldspar is quite abundant in the upper beds, and at the top comprises 10 to 25 per cent of the rock.

The Owens-Illinois plant operates from the lower beds and produces a high silica sand. The Pacific Clay Company operates from the upper level and processes a feldspathic sand.

The sand development in Ione is a joint operation between Gladding McBean & Company and Owens-Illinois Glass Company. It was designed to recover the clay and the sand. The location is about one mile west of the town of Ione. The deposit under operation is approximately 70 feet thick with about 60 per cent sand and 40 per cent clay. The formation is very soft and permits mining by a dragline. The crude sand is washed in a log washer, diluted to 40 per cent solids and pumped to the main plant. The slurry is deslimed in a series of wet cyclones. The clay portion is pumped to the adjacent plant of Gladding McBean and Company for further treatment and refinement.

The quartz sand is conditioned for flotation with suitable reagents. The heavy mineral fraction is removed in a series of twelve Fagarton Cells. The reagents are adjusted to remove all such minerals as illmenite, rutile, magnetite, hematite, garnet and zircon. The concentrate is wasted. The floated sand is washed, filtered to constant moisture, and dried. Shipment can be made by truck or rail.

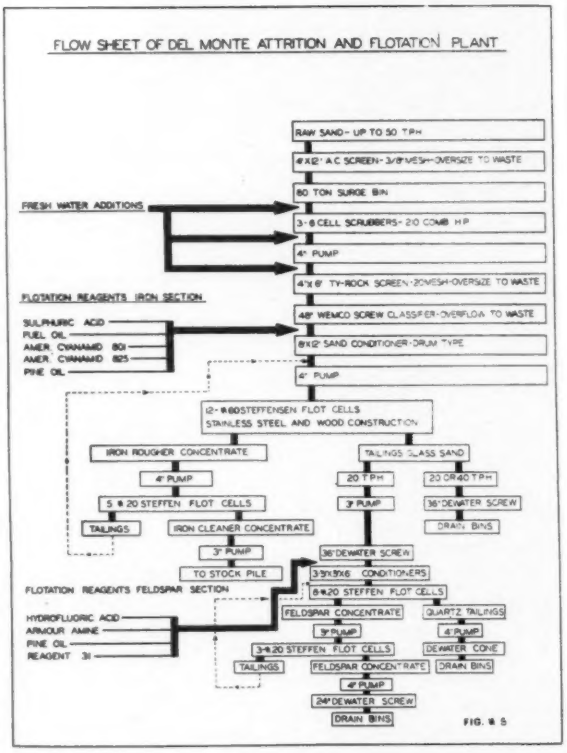


Fig. 3

The sand is of the finest quality available. The iron content ranges from .014 per cent to a high of .020 per cent. The silica content is 99.45 per cent.

The sand operation of Pacific Clay Company is located in Camanche, about thirty miles east of Stockton, California. The mining is done hydraulically in a quarry now developed to a depth of fifty feet. The deposit is estimated at 22,000,000 tons of sand. The water pressure for the hydraulic operation is about 175 pounds.

From the mine the sand and clay slurry is delivered by a dredge-type pump to a scalping screen. The undersize or screened sand is pumped to a spiral classifier

(*Continued on page* 509)

Recent Translations of Russian Papers of Interest to the Glass Industry

Determination of the Thermal Expansion of Glass

In 1936, B. V. Rabinovich suggested a simple method for the relative determination of the coefficient of thermal expansion of glasses. A more detailed study of this method by V. L. Indenbom appeared in *Steklo i Keramika* (*Glass and Ceramics*) *12*, No. 4, p. 9 (1955).

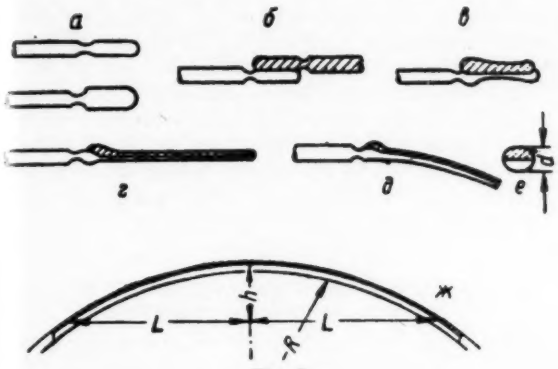


Fig. 1

Two filaments, each of a different glass, are fused together lengthwise so that the cross-section of the composite filament looks like that illustrated in 1 e. When the temperature of the filament varies, that component of the filament which has a greater expansion coefficient (α) changes its length more than the other component does, and the composite filament bends (as in bi-metal thermoregulators). If temperature decreases, the component with the greater α is found on the inside of the bend; and an increase in temperature makes this component to be on the outside of the bend.

If T_1-T_2 is temperature change, d the thickness of the composite filament normal to the plane of fusion and R the radius of the curvature of the bend, then the difference ($\triangle\alpha$) between the expansion coefficients of the two glasses can be calculated from the equation

$$\triangle\alpha = \frac{3\pi d}{16R}\,\frac{1}{T_1\text{-}T_2}$$

The α of one of the glasses is known beforehand; then the unknown expansion coefficient is $\alpha+\triangle\alpha$. To determine R, consider two points on the filament such that the length of the cord connecting them is $2L$. If the distance between this chord and the apex of the curve formed by the filament is h, then

$$R = \frac{h^2 + L^2}{2h}$$

In the usual test, the filaments are fused together at a temperature above the "solidification temperature" and are allowed to cool to the room temperature at which the curvature of the filament is measured. Hence, T_1 is the "solidification temperature" and T_2, room temperature. Assuming T_1-T_2 to be approximately constant for different glasses and different experiments, the simple formula is derived:

$$\triangle\alpha = 0.0014\,\frac{hd}{L^2\text{-}h^2};$$

h, d, and L must be expressed in identical units. It was found convenient to keep also L constant and equal to 100 mm.

Fig. 1 illustrates the making of a composite filament. Start from glass rods, about 5 mm. thick and 150 mm long. Heat their ends and squash these to "trowels" of about 15x10x4 mm. Put the trowel blades one above the other and heat, see Fig. 1σ. Compress the double blade and remove one of the rods. (Fig. 1β). Pull the double blade to a double filament (Fig. 1ι). Break off the end of the filament (Fig. 1∂). Pull out double filaments (about 250 mm long) from the stub. Determine their curvature after cooling.

The filaments used for the measurement should be 0.1-0.3 mm thick and the thickness variation along the length of the filament should never exceed 0.02 mm.

The method was tested in two respects. According to the above equations, for a given pair of glasses, d/R should be constant, that is R should be proportional to the diameter (d) of the composite filament. Fig. 2 shows that the expectation is confirmed for R between about 100 and about 300 mm. and for d between 0.1 and 0.3 mm. Also comparison of values for the coefficient of expansion found by the new and a standard method proves the reliability of the new procedure. The error of the determination of $\triangle\alpha$ is $\pm 10^{-8}$ degree $^{-1}$ as long as $\triangle\alpha$ is less than 10^{-7}, and ± 10 per cent at $\triangle\alpha > 10^{-7}$.

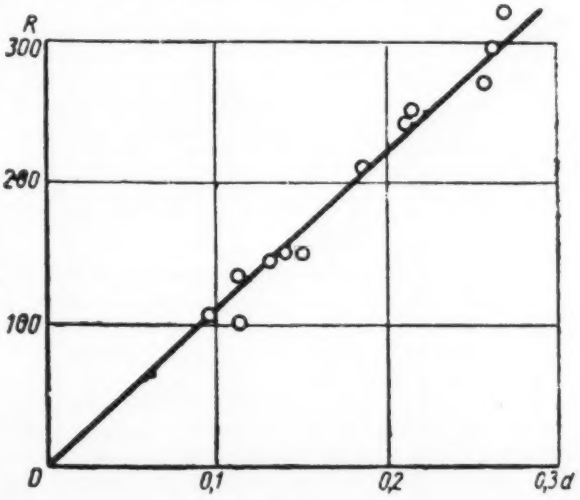


Fig. 2

Structure of Etched Glass Surfaces

V. I. Shelyubskii published some electron microphotographs in *Steklo i Keramika* (Glass and Ceramics), *11*, No. 10, p. 19.

A lead glass and a borosilicate glass were etched in 20-40 per cent hydrofluoric acid. Silica replica of their surfaces were made and photographed in an electron microscope. On many photographs chain-like formations were visible. They were of two kinds.

The "angular" chains were over 4 microns long and 70 to 700 Angstroms thick. Their conspicuous feature was branching at angles where near to 120°. The "meandering" chains also were long (reaching across the whole field of the electron microscope) but much thicker than the "angular" ones, namely 200 to 1000 Angstroms; they had no definite branching angle and almost completely covered some areas.

No explanation is offered by the author but he emphasizes the difference between his photographs and those relating to unetched glass and published by Terao and Okaba in THE GLASS INDUSTRY 34, No. 2, p. 1 (1953).

Formation of Glass Batch Briquettes

This was studied by L. G. Melnichenko, *Steklo i Keramika* (Glass and Ceramics) *11*, No. 11, p. 9 (1954).

The most usual batches in Russia contain sand, sodium carbonate, sodium sulfate and chalk. To see which ingredients are beneficial for briquette formation, Melnichenko prepared briquettes from one or two components (plus water). In all instances the water content was 6 per cent and the pressure during formation 250 or 500 kg. wt./sq. cm. (equal to 3500 or 7000 psi).

The briquettes made of sand only had no crushing strength, those of sodium carbonate 80 kg.wt./sq. cm., sodium sulfate 40 kg.wt./sq. cm., and chalk 20 kg.wt./sq.cm. The crushing strength of mixed briquettes of sand + soda, sand + chalk, and soda + chalk was roughly a linear function of the composition, but in the system Na_2CO_3—Na_2SO_4 it had a maximum at 10-15 per cent Na_2SO_4.

Thus, the sodium salts determine the strength of the briquette. Each of these salts forms several hydrates, and the strength of the briquette depends on what hydrates existed in it before the steady state was reached. Thus, Melnichenko found that if the pressing of the batch was carried out above the transformation temperatures of 32-35°C, the cooled briquette was, e.g., 5 times as strong as a briquette pressed at room temperature.

Calculation of The Productivity of A Small Glass Furnace

N. A. Sheludyakov, in *Steklo i Keramika* (Glass and Ceramics), *11*, No. 4, p. 26 (1954), describes a calculation of the amount of glass which can be removed from a furnace without contaminating the glass with batch particles or air bells.

In the melting part of the furnace the glass layer is covered with a silicate layer still containing sand, and this silicate is covered with batch. No batch particles are carried along with the glass melt as long as the silicate layer remains stationary, i.e. the rate of silicate formation is equal to that of glass formation. The first named rate is $Q : A$; Q is the heat supplied to 1 sq. meter of batch surface, and A is the heat required to form 1 kg. of the silicate layer. At 1450°C, Q is known to be 67 000 cal./hour. A is about 705 cal./kg. Hence, the rate of silicate formation is

$$\frac{67000}{705}$$

= 96 kg/hr for 1 sq. meter. The rate of glass formation is $P = \frac{h\tau e^{bt}}{a}$; h is the thickness of the silicate layer (assumed to be 10 cm), τ is specific gravity of glass melt, t is temperature, and a and b are constants (a = 101250, b = 0.00815).

This equation gives for P the value of 95 kg./hr. at 1300°C. Thus, when the furnace temperature is 1450°C and the melt temperature is 1300°C, the silicate layer remains stationary at 10 cm. thickness.

In the fining part of the furnace, the rate of rise of bubbles should be greater than the rate of descent of the glass level because of the glass flow toward the machine end. E.g., at 1300°C bubbles 1 mm. in diameter would rise 860 mm. in 24 hours. If a thicker layer of glass melt is used in this time, air bubbles will be present in the final product.

L.O.F. GLASS FIBERS AND GBBA REACH WAGE AGREEMENT

A new wage agreement providing an average increase of five cents per hour was signed by officials of L.O.F. Glass Fibers Company and the Glass Bottle Blowers Association, Local #54, it was announced by James D. McGee, general personnel director for the company and Wesley Bromberg, executive officer of the GBBA.

The agreement, retroactive to April 1, 1957, covers the majority of hourly employees at the company's Waterville plant. It was negotiated following the expiration of a former five-year contract.

The new agreement expires on November 1, 1960 and provides reopening for wages and wage-related matters only on November 1, 1958 and Novmber 1, 1959.

The Waterville plant, established in 1944, is the company's original facility and presently employs 400 hourly workers.

Glass fiber textile yarn, bonded mat and specialized insulation products are manufactured at the plant.

R. J. DELARGEY PROMOTED BY WESTVACO CHLOR-ALKALI

Robert J. DeLargey has been named assistant division manager, operations, of the Westvaco Chlor-Alkali Division of Food Machinery & Chemical Corporation. He will have direct charge of the Division's production, research, and development activities, according to an announcement made by Franklin Farley, president of the Westvaco Chlor-Alkali Division.

Mr. DeLargey formerly was director of engineering for FMC's Chemical Divisions. Previous to this, he was resident manager for FMC's largest chemical unit, the South Charleston, W. Va. plant of the Westvaco Chlor-Alkali Division. Earlier he had been division production manager and director of engineering for the Westvaco organization.

Inventions and Inventors

Annealing and Tempering

Burners For Reheating Stemware. Patent No. 2,776,526. Filed August 1, 1951. Issued January 8, 1957. Four sheets of drawings; none reproduced. Assigned to Owens-Illinois Glass Company by John H. Beddoes and John J. Suchocki.

This invention relates to the forming of glassware such as footed tumblers or stemware and particularly to burners for reheating the supporting foot or base on glass stemware prior to re-shaping.

A burner is provided for directing flames onto the interior surface of the cup-shaped foot and a second burner is provided for directing flames onto the exterior surface of the cup-shaped foot. The burners are so designed and constructed that they will heat the foot uniformly without producing cold spots or hot spots which form blisters on the surface of the glass. The cup-shaped foot is also heated without heating the stem to a point where it will be distorted or marred.

There were 3 claims and 11 references cited in this patent.

Feeding and Forming

Feeder For Sheets of Glass and Similar Thermoplastic Materials. Patent No. 2,772,517. Filed October 9, 1952. Issued December 4, 1956. One sheet of drawings; none reproduced. Assigned to U.S.A., by Urban E. Bowes.

The present invention comprises the provision of a metallic feeder body having a multiplicity of glass receiving channels which have their entrance ends associated with a common supply; each is feeding, in parallel, a common rectangular discharge orifice. The receiving channels and discharge orifice may conveniently be formed in a single massive wide member capable of excellent dimensional stability and of being easily maintained at uniform temperature. The channels are constantly flooded by or immersed in molten glass and the sheet which issues therefrom has uniform edges and planar surfaces that require less than usual grinding and polishing.

There were four claims and the following references cited in this patent: Re. 21, 863, Slayter, July 22, 1941; 770,832, Taylor, Sept. 27, 1904; 840,838, George et al., Jan. 8, 1907; and 1,954,732, Gossler, Apr. 10, 1934.

Furnaces

Refractories. Patent No. 2,764,491. Filed April 28, 1951. Issued Sept. 25, 1956. One sheet of drawings; none reproduced. Assigned to American Optical Company, by Carl G. Silverberg.

One of the principal objects of this invention is to provide a refractory for supporting and forming lead-containing glass articles by the heating and dropping process. The said refractory will obviate any tendency of the articles to adhere thereto during the heating operation and in addition will possess desired characteristics as to heat conductivity and expansion whereby the said refractories may be employed in repetitive heating and dropping of a plurality of articles of consistently similar shapes and optical characteristics and without reworking the surface of the refractory.

A preferred composition is as follows:

	Grams
Silicon carbide	3200
Ball clay	800
Ammonium oxalate	8
Ammonium hydroxide	½
Triethanolamine	2
Water	1000

The above formula produces a fluid composition which is particularly suitable for use in forming refractory articles by casting methods.

Although the preferred composition has been found to be substantially that set forth, it is to be understood that the amount of ball clay may be varied from 5 to 40 per cent of the total composition. Silicon carbide has a tendency to shrink on heating during the fabrication thereof, which characteristic also is true of ball clay so that allowance must be made during drying and firing of the refractories being formed. It has been found that by making the refractories initially larger by an amount sufficient to compensate for the shrinking, the resultant articles may be formed to the final shape and size desired.

The amount of dispersing agents used must be maintained at a minimum to avoid vitrification of the refractory ingredients which might result from a reducing atmosphere and to prevent flux and possible adhesion characteristics in the resultant refractory, whereby glass articles subsequently dropped thereon will not adhere to the refractory. The amount of ammonium oxalate and ammonium hydroxide solution used, therefore, should be only that which is sufficient to bring about the desirable working characteristics without adhesion. Although ammonium oxalate and ammonium hydroxide have been set forth as the preferred dispersing agents, it is to be understood that either or both of said materials may be replaced by one or more of the following ingredients: sodium silicate, sodium carbonate, morpholine, lignin, sodium gallate, etc., or tannic acid or any other known dispersing agent or agents.

With proper temperature and time controls, a refractory formed of the above material or compositions will produce very satisfactory results with no danger of adhesion of glass material of the article being dropped to the refractory during the heating operation.

There were 3 claims and the following references cited in this patent: 2,272,038, Morgan, Feb. 3, 1942; and 481,239, France, 1916.

Glass Wool and Fiber

Glass Fiber Twine. Fig. 1. Patent No. 2,706,377. Filed April 28, 1951. Issued April 19, 1955. One sheet of drawings. Assigned to Owens-Corning Fiberglas Corporation by Games Slayter.

It is the object of this invention to provide a method by which glass fiber strands can be introduced into and with sisal fibers in the fabrication of baler and binder twines having substantially the same characteristics as all natural fiber twines. During the production of the glass fiber strands which are carried by the belt 12, Fig. 1, each of the approximately two hundred fibers in each strand is coated with a suitable hardenable synthetic resin, for example a thermosetting resin such as phenol formaldehyde, and the resin is polymerized to form a stiffening coating on the fibers and bind the fibers together in the strand. This makes the fibers and the strands

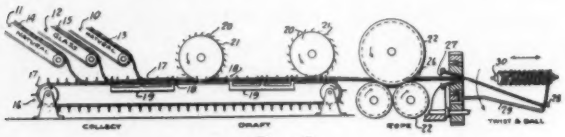


Fig. 1

wiry and tough, reducing their flexibility and approximating natural sisal fibers with which the glass fibers are to be interworked. Suitable glass fiber strands are carried by the belt 12 and deposited in successive layers on a travelling conveyor belt 16 which moves horizontally beneath the lower ends of the belts 10, 11 and 12. The belt 16 is provided with a multiplicity of pointed fingers 17, extending upward which serve to pull the fibers from the belts 11, 12 and 13 and to commence their orientation into general parallelism over the surface of the bicycle chains making up the belt 16. As the fibers progress along the belt 16 they gradually become more tightly compacted by virtue of the combining or drafting and finally are led between compacting rollers 22 which have concave grooved peripheries for the purpose of forming the fibers into a bundle of generally circular cross sections.

The patent contains three claims and the following references were cited: 2,133,237, Slayter, Oct. 11, 1938; 2,133,238, Slayter et al., Oct. 11, 1938; 2,132,702. Simpson, Oct. 11, 1938; 2,293,918, Planiol, Aug. 25, 1942; 2,616,239, Holcomb, Nov. 4, 1952; and Sherman and Sherman, *The New Fibers*, p. 128 (1946).

Sheet and Plate Glass

Glass Grinding Machine. Fig. 2. Patent No. 2,719,388. Filed March 19, 1952. Issued October 4, 1955. Two sheets of drawings. By Paul J. Pilger.

This invention relates to glass grinding machines and more particularly to a machine for accurately and speedily grinding the longitudinal edges of the glass panels or louvers commonly employed in glass jalousies.

As shown in Figure 4, as the louvers travel longitudinally along the machine, under the influence of the carriages being propelled by the chain 18, their lower edges ride over and in grinding contact with rapidly revolving surfaces of grinding wheels 31. The louvers are free to shift vertically between the plates 11 and during their travel, their lower edges ride over rollers 22, which are preferably covered by rubber. During their travel, the louvers ride beneath rubber covered pressure rollers 23, which exert an adjustable downward pressure under the influence of weights 24. The weights are calculated to exert the proper pressure upon the upper edges of the louvers for maintaining the lower edges in grinding contact with grinding wheels. Each carriage 10 is provided with transversely disposed cushioning strips 28 and 29, with the strips being grooved, as shown at 30, to have straddling seating engagement over the plates, and the strips 29 and 28 provide cushioning abutments for the end portions of the louvers to prevent chipping the glass as the louvers are propelled through the machine.

An air blast is provided that overlies the group of louvers adjacent to the discharge end of the machine whereby air is jetted between the several parallel louvers for removing all the water that has accumulated on the louvers during the several grinding stages.

There was one claim and the following references cited in this patent: 1,680,920, Weber, Aug. 14, 1928; 1,687,985, Mermer, Oct. 16, 1928; 1,906,329, Mermer, May 2, 1933; 1,937,388, Kranich, Nov. 28, 1933; 2,160,085, Robertson, May 30, 1939; 2,531,640, Oberstar, Nov. 28, 1950; and 2,573,936, Thede, Nov. 6, 1951.

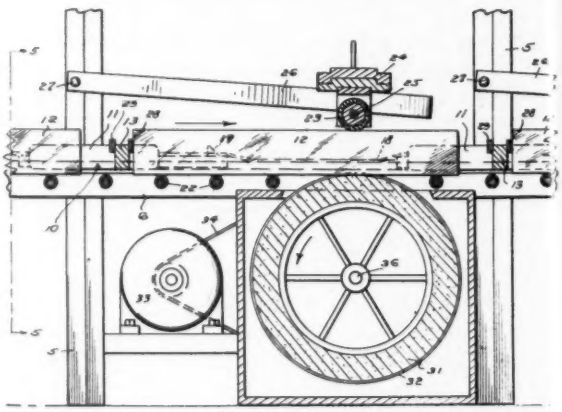


Fig. 2

Grinding and Polishing Glass. Patent No. 2,757,494. Filed June 12, 1951. Issued August 7, 1956. No drawings. Assigned to U.S.A. by Charles E. Chaudron.

The invention consists in no longer using the abrasive medium in the form of a suspension in a liquid, but in the form of an agglomerate with an associated binder in order to obtain a coherent body to which may be imparted the shape of a body having definite sizes, for example a disc, suitable as a tool for performing grinding and polishing operations.

According to another feature of the invention, there are incorporated in the agglomerate materials which by nature are comparatively soft and, preferably, in addition, may be easily impregnated with a binder to impart to the agglomerate or shaped body some degree of resiliency and a good cohesion.

Such materials may be various kinds of fibres of animal, vegetal or mineral character, wood sawdust, paper or similar, substances.

In the grinding-polishing of flat glass on a test machine, on which the advance of the work was 75 cms. per minute, with a linear velocity (mean rotation speed) of the tool of 4 m. per second and with a working pressure of 6 to 7 kgs. per square decimetre, the polishing was affected with disc shaped tools having a diameter

(*Continued on page* 518)

Research Digest

Radiation Coloration in Glasses

• THE FIRST RECORD OF the coloration of glass by radiation was by Faraday (1825) who observed that a glass containing manganese deepened in color under sunlight. Berthelot (1901) also noted that a manganese glass was affected in the same way by radium rays. Since these early observations it is now known that all forms of high energy radiation may color a glass.

Many experimental observations have been recorded on the effects of different types of radiation on various glasses, and excellent surveys appear in the literature. The mechanisms of coloration, however, are still far from understood. In the February 1956 issue of the *Journal of the Society of Glass Technology* M. Levy discusses possible mechanisms of coloration and inhibition and attempts to correlate these experimental observations.

An electron may be excited into a higher state by the absorption of a photon of energy 1·5 e.v.-3·0 e.v. If this excited electron drops back to its initial state then the same photon of energy is emitted over a solid angle of 4π and thus only a negligible portion of it travels along the direction of the incident light path. The absorption due to this excitation gives rise to an absorption band in the visible range, the coloration depending on the position, width, and height of this band.

There have been a great number of observations on the coloring properties of various metal ions in glass without radiation treatment which will not be dealt with in detail.

The heavy metal ions such as gold, silver, and palladium are easily reduced to the metallic state and thus give rise to a colloidal coloration in glass. This is a particle coloration and not a coloration arising from electron transitions within the glass proper.

Briefly, the natural (i.e. not radiation induced) color given to a glass by a particular transitional metal ion depends upon three factors:

(1) Co-ordination number of the ion.
(2) Whether the ion is a network former or modifier.
(3) Valency state of the ion as governed by the oxidation-reduction nature of the batch, melting conditions and the composition of the base glass.

All the transition metal ions may change their valencies under suitable oxidizing or reducing conditions and such conditions may result from ionising radiations. The transition metal ions have relatively high cross-sections for high energy radiation and so tend to become preferentially oxidized by electron loss to give a higher valency state. Monk (1952) pointed out that for one multivalent ion to be oxidized there must be another multivalent ion that may be reduced, i.e. radiation of a glass containing ferric and manganous ions may bring about the reaction:

$$Fe^{3+} + Mn^{2+} \rightarrow Fe^{2+} + Mn^{3+}$$

Experimental observations support the model that there must be both an electron donor and an electron acceptor for any transition cation to change its valency. Both in solarization and high energy radiation Faraday and others observed oxidation of the manganous ion to the manganic ion, while others have reported oxidation of the ferrous ion to the ferric ion. However, the cerium and nickel ions have been observed to be unaffected by X-irradiation and solarization of a glass containing the vanadic ion caused a reduction to the vanadous state. The observations that in some cases cations are oxidized, in some cases reduced, and in others not affected, intimate the presence of some other cation in the glass, which acts as a preferential oxidizing or reducing agent.

It should still be borne in mind that a possible way of inhibiting coloration in glass is by providing an easily reduced cation in preference to a center similar to the centers in the alkali halides. However, there has been no report of the reduction of any ion under high energy radiations other than the reduction of the vanadic ion by ultra-violet light.

The F-centre coloration in the alkali halides is thought to be due to an electron trapped at a negative ion vacancy and so it is feasible that glass, having a partly ionic character, might exhibit a similar trapping center. The most obvious imperfection that can act as a trapping center in a glass is an oxygen ion vacancy. This center may be called a G-center for convenience. As each G-center would probably be in the vicinity of a particular group of cations it would only in a one-, two-, or three-oxide component glass that each G-band could be separately identified. Such appears to be the case.

Commercial and optical glasses contain a large number of oxides and, consequently, if one G-band were associated with each cation, the absorption spectrum of the irradiated glass should appear as a superposition of all these bands to give a general absorption. The observations of Monk and Best on the X- and gamma-ray irradiation of optical glasses show that a broad general absorption is produced, without any distinct maxima. The literature indicates that the color produced in a certain glass by high energy radiation depends only on the glass and not upon the source of radiation, an observation first made by Lind. The silicate glasses go brown, the borate glasses purple and the phosphate glasses pink.

Assuming that the coloration in glass is due to G-centers, one method by which inhibition can take place is by reducing the number of negative ion vacancies. Schulman et al. have proposed a mechanism which explains the first phenomenon, and Varley, in his observations on the effects of electron irradiation on the alkali halides, has proposed a mechanism explaining the second phenomenon.

Schulman's mechanism is briefly as follows: substitution of an M^{3+} ion in an M^{2+} salt would cause one positive ion vacancy to be formed in the region of the M^{3+} ion to provide the necessary charge compensation. Similarly, substitution of an R^{-} ion in an R^{2-} salt would also cause one positive ion vacancy to be formed. These positive ion vacancies are not electron traps and, by interaction with negative ion vacancies, would form vacancy pairs; in doing so they would reduce the number of effective negative ion vacancies. Hence the number of

effective electron traps would be lowered and the matrial would exhibit inhibition towards radiation coloration.

On the sensitization of the alkali halides towards X-irradiation, Varley has suggested that ions may be displaced by multiple ionization displacement. The cross-section for stripping, say, four electrons off a halogen ion is quite high ($\sim 10^{-21} cm^2$ or 10^3 barns) and such a highly positively charged halogen ion would be ejected, leaving behind it a negative ion vacancy. In the previous paragraph it has been shown that impure crystals containing M^{3+} ions replacing M^{2+} ions have an excess number of positive ion vacancies. Thus it may be seen that two processes are competing in the formation of available negative ion vacancy trapping centers.

(1) The positively charged halogen ions may become trapped at the positive ion vacancies, leaving behind a negative ion vacancy which may act as a color center. This probability increases with increasing impurity content.

(2) The number of positive ion vacancies introduced by the stoichiometric additions may be so high that they become associated with negative ion vacancies, so that the latter may not act as color centers.

It is proposed to extend both these mechanisms to glass, which is in effect a mixture of ionic or partly ionic oxides. If a substitutional cation enters a glass homogeneously, the cation will associate itself with the M^+, M^{2+}, M^{3+}, and M^{4+} ions in proportion to the relative amounts of these cations in the glass. If the substitutional cation was an M^{3+} ion, inhibition would take place in regions of M^+ and M^{2+} glass ions, regions of M^{3+} ions would be unaffected and M^{4+} ion regions would be sensitized. Therefore, the G-band corresponding to each oxide has to be considered and analyzed separately and it is only by adding a cation of valency as high as or higher than the cation of highest valency in the base glass that inhibition may take place. Ceric oxide (CeO^2) has been found the most suitable additive in ordinary commercial glass, and Monk has found that glasses containing this oxide in very small quantities (1 per cent) are uncolored by 10^6 roentgens of gamma radiation.

The mechanism Varley proposed to explain the sensitization of the alkali halides by small additions of divalent cation impurities may also be extended to account for similar phenomena observed in glasses. Cohn & Harkins observed that X-irradiation of a zinc-borate glass containing cerium additions up to 0.05 per cent increased the thermo-luminescence, whereas higher additions of cerium decreased this property. Evidently, in this case, the thermo-luminescence was a more sensitive property than the G-center coloration. Nyswander & Cohn observed that traces of magnesium, calcium, strontium, barium, aluminum, manganese, nickel, cobalt, chromium, cerium, silver, thallium, or thorium oxide added to a zinc-borate glass all brought about an increase in the thermo-luminescence induced by the radiation from a carbon arc. This was most intense in the glasses containing the added cations of the highest valencies, or silver, the latter probably being due to the formation of an atomic silver thermo-luminescent center. Schmidt has also reported that additions of iron and manganese oxide up to 0.5 per cent enhanced the coloration of a glass by X-rays, greater additions causing inhibition. These experimental observations all support the models outlined above, in that small additions of cation impurities to a glass cause a sensitizing of the material to radiation coloration (Varley mechanism) whereas larger additions cause an inhibition (Schulman mechanism).

It is generally thought that the bonding in glass is not fully ionic but is partly of homopolar character. The effect of high energy radiation on the co-valent polymers has been observed to cause the ultra-violet absorption edge or band to move towards longer wavelengths. If the period of irradiation is sufficiently prolonged it first causes the material to become colored yellow, then orange, and finally deep red. A similar phenomenon has been observed in fused quartz but the movement of the absorption edge or band was not enough to cause any yellowing of the glass. It is feasible that all glasses, having in part a covalent bonding character, may exhibit this phenomenon with sufficiently long periods of irradiation. However, nothing has yet been reported on this subject and further research is required.

APPOINTMENTS AT UNION CARBIDE

R. S. Abrams has been appointed General Manager and L. J. Sinnott has been appointed, general sales manager of the Silicones Division, Union Carbide Corporation, it was announced by W. B. Humes, president of this division.

Mr. Abrams joined the Union Carbide organization in 1941 when he went to work for Linde Air Products Company, Division of the Corporation, in Tonawanda, New York. From 1943 to 1946 he held various positions at Linde's ceramics plant there under the Army's Manhattan District project. He was transferred to Chicago in 1946 as superintendent of Linde's alum plant. In 1947, he returned to Tonawanda to work on various aspects of silicones research, development, design, and plant operation. He became manager of the silicones plant at Long Reach, West Virginia, in 1955. Earlier this year, Mr. Abrams was appointed manager of production and engineering for the Silicones Division which was formed in 1956 to take over the business of Linde's Silicones Department. Mr. Abrams was born in Minneapolis, Minnesota. He received the degrees of B. S. and M. S. in Chemical Engineering from the University of Minnesota.

Mr. Sinnott joined Union Carbide in 1942 as a development engineer for Linde Air Products Company in Newark. The following year he moved to the Cleveland Sales Office, later becoming sales manager in the Disttrict Office at Denver, Colorado, then manager of the Pacific Northwest District Office at Seattle, Washington. In 1951 he was transferred to the New York Office of Linde to fill a staff position in market development work. Two years later he became sales manager for Linde's Silicones Department. Mr. Sinnott is originally from Cleveland, Ohio. He was graduated from Case Institute of Technology in 1942 with the degree of B. S. in Chemical Engineering.

● Robert E. Frey, for the past six months assistant works manager, operations of Diamond Alkali Company's Painesville Plant, has been named to the newly created position of assistant works manager, it was announced here today by M. O. Kirp, works manager.

Current Statistical Position of Glass

Employment and payrolls: Employment in the glass industry during June, 1957 was as follows: *Flat Glass:* A preliminary figure of 27,200 for June, 1957 indicates a decrease of .07 per cent from the adjusted 27,400 reported for May, 1957. *Glass and Glassware, Pressed and Blown:* An increase of 1.1 per cent is shown by the preliminary figure of 82,600 for June, 1957, when compared with the adjusted figure of 81,700 for May, 1957. *Glass Products Made of Purchased Glass:* The preliminary figure of 13,900 for June, 1957 indicates an increase of .07 per cent from the previous month's adjusted figure of 13,800.

Payrolls in the glass industry during June, 1957 were as follows: *Flat Glass:* A decrease of 11 per cent is shown in the preliminary $12,723,806.50 when compared with May, 1957's adjusted $14,281,849.99. *Glass and Glassware, Pressed and Blown:* An increase of 1.4 per cent is shown in the preliminary $30,214,407.64 reported for June, 1957 when compared with the previous month's adjusted $29,892,275.00 figure. *Glass Products Made of Purchased Glass:* A preliminary figure of $4,134,097.97 was reported for June, 1957. This is an increase of 2.4 per cent when compared with the adjusted figure of $4,039,179.27 for the previous month.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers

	July, 1957
Food	1,350,000
Medicinal and Health Supplies	1,209,000
Chemical, Household and Industrial	786,000
Toiletries and Cosmetics	846,000
Beverage, Returnable	1,017,000
Beverage, Non-Returnable	160,000
Beer, Returnable	349,000
Beer, Non-Returnable	998,000
Liquor	603,000
Wine	302,000
Sub-total (Narrow)	7,670,000

Wide Mouth Containers

Food	*3,537,000
Medicinal and Health Supplies	374,000
Chemical, Household and Industrial	177,000
Toiletries and Cosmetics	190,000
Packers' Tumblers	67,000
Dairy Products	179,000
Sub-total (Wide)	4,524,000
Total Domestic	12,194,000
Export Shipments	236,000
TOTAL SHIPMENTS	12,430,000

*This figure includes Fruit Jars and Jelly Glasses.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production July, 1957	Stocks July, 1957
Food, Medicinal and Health Supplies; Chemical, Household and Industrial: Toiletries and Cosmetics	Narrow Neck	4,422,000	6,785,000
	Wide Mouth	4,359,000	*5,819,000
Beverage, Returnable		958,000	1,591,000
Beverage, Non-Returnable		150,000	236,000
Beer, Returnable		393,000	446,000
Beer, Non-Returnable		984,000	667,000
Liquor		728,000	1,334,000
Wine		304,000	664,000
Packers' Tumblers		60,000	102,000
Dairy Products		207,000	311,000
TOTAL		*12,565,000	*17,955,000

*This figure includes Fruit Jars and Jelly Glasses.

Glass container production: Production based on figures released by the Bureau of Census was 12,565,000 gross during July, 1957. This represents a decrease of 1.5 per cent from the previous month's production of 12,747,000 gross. During July, 1956, glass container production was 12,158,000 gross or 3.3 per cent under the July, 1957 figure. At the end of the first seven months of 1957 glass container manufacturers have produced a preliminary total of 84,843,000 gross This is 2.3 per cent over the 82,921,000 gross produced during the corresponding 1956 period.

Shipments of glass containers during July, 1957 were 12,430,000 gross, or an increase of 1 per cent from June, 1957 shipments which were 12,309,000 gross. Shipments during July, 1956 were 11,446,000 gross or 8.6 per cent under July, 1957. At the end of the first seven months of 1957 shipments have reached a total of 80,367,000 gross, which is 1.7 per cent over the 79,009,000 gross shipped during the corresponding period last year.

Stocks on hand at the end of July, 1957 were 17,955,000 gross. This is .05 per cent above the 17,860,000 gross on hand at the end of June, 1957 and 6.8 per cent higher than the 16,810,000 gross on hand at the end of July, 1956.

Automatic tumbler production: During June, 1957 this production was 4,584,000 dozen. This is a loss of 2.5 per cent from the June, 1956 production which was 4,701,000 dozen.

Shipments during June, 1957 fell to 4,505,000 dozen. This is 13.7 per cent lower than the 5,222,000 dozen shipped during June, 1956. At the end of the twelve months period ending June 30, 1957, shipments have reached a total of 54,662,000 dozen which is 9.8 per cent lower than the 60,608,999 dozen shipped last year.

Table, kitchen and household glassware: Manufacturers' sales of machine-made table, kitchen and household glassware during June, 1957 reached 2,585,000 dozen. This is 10.6 per cent over the 2,338,000 gross of June, 1956. At the end of the twelve months period ending June 30, 1957, manufacturers had sold a total of 34,678,000 dozen, which was 3.4 per cent lower than the 35,896,000 dozen sold during the corresponding period last year.

New Equipment and Supplies

BALL TABLE TRANSFER STAND

M-H Standard Corporation, 513-521 Communipaw Avenue, Jersey City 4, N.J., offers its new "Traffic Circle" ball table transfer stand. It is used as a junction for two, three, or four gravity conveyor lines and is said to permit easy routing of objects from any one line to any of the others. It is also useful where it is desired to cover a broad area by shifting a gravity conveyor. In such a case, the transfer stand acts as a variable angle gravity curve.

The mechanism consists essentially of a circular ball caster table on three adjustable legs. At the outer rim of the table are four support brackets for the gravity conveyor. These brackets are free to slide completely around the table so that any pattern of conveyor junction can be obtained, yet are completely retained so that they cannot be removed without tools.

Legs are spread with generous foot pads for stability. Hand knob adjustment with safety grip locks permit rapid adjustment up to 6 inches for height or to compensate for floor irregularity. Legs may be removed for compact shipment or storage when not in use. The support brackets will accommodate gravity conveyors up to 18 inches wide.

NEW FLEXIBLE LINK SHAFT

Clark Flexible Link Shaft Company, Box 73, Newton Highlands 61, Mass., has available a new flexible link shaft with equal torque in both directions, unlimited length and equal flexibility in all sizes from ⅜ inch to 3 inches diameters. The link shaft is said to be suitable for remote controls and power drives.

The links consist of trunnion blocks and two half links fastened together with screws or rivets in a construction for which patents are pending. Cover materials are available in a variety of materials including armored neoprene hose, non-metallic hose or semi-rigid tube. End fittings are available to meet given requirements. Minimum link length is three times the diameter and various link lengths can be combined in one shaft using long links for straight runs.

Torque rating for manual torsional movements are 50 in. lbs. for ⅜ inch shaft, 200 in. lbs. for ½ inch shaft and 2500 in. lbs. for 1¼ inch shaft. For motor drives at 1750 RPM ⅛ inch HP requires ⅜ inch shaft, 1/3 HP requires ½ inch shaft and 1 HP requires ¾ inch shaft.

Long life is characteristic of the shafting. For example, on railroad diesels this shafting has operated continuously for 7000 hours at 900 RPM without attention or maintenance.

CELL TRANSMITTER MEASURES SMALL FLOWS

The Foxboro Company, Foxboro, Mass., is now marketing a new integral orifice d/p cell transmitter, which measures and transmits small flows, below rotameter range, with a minimum range of 0.003 to 0.010 gpm of clean water and similar liquids and from 0.010 to 0.040 scfm of air and other gases.

An adaptation of Foxboro's force balance type 13A d/p cell transmitter, the new instrument has a manifold with a removable orifice through which the measured fluid flows. Resulting pressures across the orifice are applied to the high and low pressure sides of a standard silicone-filled twin diaphragm capsule. The resulting differential, balanced by a pneumatic feedback mechanism, produces a 3-15 psi output signal proportional to differential pressure for remote indication or recording.

Six standard orifices in bore sizes from 0.020 to 0.250 inches are available with the transmitter. Simple removal of manifold permits change of the orifice for new flow range. A conversion kit containing set of orifices and manifold is also available so that existing transmitters of the 13A type can be converted in the field to measurement of small flows.

Since the transmitter is installed directly in a process line, it needs no separate primary device and therefore no meter leads. Transmitter range is adjustable between the limits of 0-20 and 0-250 inches of water. Maximum working pressure is 1500 psi; maximum working temperature, 250 F.

CATALOGS RECEIVED

Beckman Instruments, Inc., 2500 Fullerton Road, Fullerton, Cal has issued a five-bulletin package to describe their electrodes and meters. Eight page bulletin 86-5 features Beckman pH electrodes for laboratory and portable pH meters. The electrode bulletin is made up in unique, simplified chart form, completely indexed and illustrated to guide users in selecting correct pH electrodes. The other bulletins include information on the Zeromatic, Pocket pH, and other Beckman pH meters. The package is obtainable without charge from the Scientific Instruments Division of the company.

Watts Regulator Company, Lawrence, Mass. has available a folder on their pneumatic specialties. The four page, illustrated brochure covers filters, regulators, lubricators, combination units, pressure regulators, and air relief valves and strainers. Ask for folder F-15B.

J. H. France Refractories Company, Snow Shoe, Pa. has announced the issuance of Bulletin No. 600 containing detailed information on their complete line of high temperature refractory mortars. This new publication is a six-page bulletin with illustrations of tests and applications as well as the products themselves, providing general and technical data on eleven regular and special grade mortars.

American Potash and Chemical Corporation, 3030 West Sixth Street, Los Angeles 54, Cal. has issued a complete 12 page products catalogue and informational booklet. Description, properties and applications of nearly 70 chemicals marketed by the company is included. Among major product groups listed are boron chemicals, soda products, potassium compounds, bromines, lithium products, electrochemicals, agricultural chemicals and refrigerants. The brochure also includes information on newer lithium and boron chemicals in developmental stages, which are finding interest in the rocket and missile fields as well as other industrial processes. In addition to product information, the booklet contains material on AP&CC's research and development program, the quality control program and the various AP&CC facilities located at Los Angeles, Whittier and Trona, Calif.; Henderson. Nev.; San Antonio, Texas, and West Hanover, Mass.

Bausch & Lomb Optical Company, 635 St. Paul Street, Rochester 2, N.Y. has published a new 20 page booklet describing and illustrating its new series R research microscopes. The booklet discusses the firm's 14 different research microscope models in detail. Also included is information on a full line of accessories and a current price list. The booklet may be had free of charge. Request booklet D-1057.

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(*Continued from page* 500)

for removal of the minus 150 mesh material which is about 30 per cent of the mined material. The deslimed sand from the spiral classifiers is elevated by a belt conveyor and distributed along the length of a drain slab having a wet storage capacity of 5,000 tons. Feed chutes, spaced at intervals along the center line of slab, draw the sand to a conveyor belt housed in an 84-inch Armco plate tunnel.

The pulp is next subjected to severe attrition scrubbing. It is then sized and goes to a rake-type classifier for dewatering in preparation for high solids conditioning. In the conditioning, the control of the Ph and percent solids is extremely important. Flotation reagents are the fatty acids supplied by the American Cyanamid Company. All collector reagents are added in stages during the conditioning step. The Ph modifier is soda ash added directly to the flotation circuits.

The large variety of minerals (hematite, andalusite, zircon, tourmaline, rutile, illmanite) require complete removal. This demands a very thorough preparation of the feed prior to introduction to the flotation circuits. From flotation the sand is pumped to a dewatering classifier and is then delivered to a top-fed drum filter. Here the moisture is reduced from twenty to five per cent. The dewatered sand goes to a storage bin from which it is fed into an oil-fired 5'-30' rotary dryer. The sand is next delivered to the feed boxes of two "Dings" magnetic separators for removal of any tramp iron and quartz iron grains which might have escaped flotation. The sand is now ready for shipment.

Corona Sand Deposit

The first development of a local sand in Southern California started with the construction of a pilot plant at the Weizel plant in Corona. Owens-Illinois later expanded the pilot plant into a processing plant to meet all glass sand requirements of Southern California.

The deposit is a soft feldspathic sand formation composed of 75 per cent quartz and 25 per cent soda and potash feldspar. Heavy earthmoving equipment is used in the mining operation and in the transportation of the crude sand to the processing plant.

The initial steps in the beneficiation process are the reduction of large pieces of sandstone, scrubbing in a "Hardinge" type mill and complete desliming, i.e., removal of the minus 200 mesh portion which goes to waste. The deslimed sand is scrubbed at 75 per cent solids in specially-designed attrition scrubbers. It is their function to scour, abrade, and scrub each grain without reducing the particle size. All surface stains of iron oxide and films of binding clays high in iron content have to be removed in this operation. The abrasive nature of the sand pulp requires rubber-lined equipment.

The scrubbed pulp is screened and separated into two fractions: The plus and the minus No. 40 mesh. The minus No. 40 mesh is again deslimed to remove all traces of clay, then dewatered, dried and passed through magnetic separators. This sand is used for colored glass since the iron content is between .06 per cent and .07 per cent.

The oversize or plus 40 mesh, which is about 75 per cent of the total, is reduced in Ball Mills to pass the 30 mesh screen. The reduced sand is again thoroughly deslimed. Dewatering, drying and magnetic separation of heavy minerals form the final processing steps. The iron content of this portion is consistently lower than .035 per cent.

It should be mentioned that the key to this low iron content is in two beneficiation steps:

a. The thorough and complete scrubbing and abrading of each sand grain, which are accomplished in the attrition scrubbers.
b. The use of the plus 30 mesh portion of the raw sand, and the reduction in the Ball Mills. It has long been recognized that the larger grains of feldspathic sands exhibit a lower iron content. This is due to reduced surface area of the large grains with less contamination from iron stains, and is also due to the quartz fraction which is lower in iron content and more abundant in the large grains.

The second source of a feldspathic sand is in Oceanside near San Diego. The deposit is an extension of the Corona formation. The Ottawa Silica Company recently purchased the entire operation there, and is now engaged in the development of the deposit and construction of a new processing plant. The sand from the present operation is too high in iron to permit its 100 per cent use in the glass batch. It is, however, used with much success as a source of feldspar in combination with Nevada sand.

Limestone

The mining and milling of limestone is so universal as to preclude further coverage in this paper. However, it might be of interest to mention that calcite limestone is mined for the glass industry. The iron oxide content averages .04 per cent. It might be of further interest to mention that the Sonora operation is an underground operation.

Glass Technology

The high alumina content of the sands discussed heretofore has presented a problem and challenge to the glass industry. The discussion of a few case histories should be of interest, particularly the use of Del Monte products. The proximity of the plant to the glass centers, with accompanying low freight rates, made the use of this sand especially attractive costwise.

One of the earliest attempts to use a high proportion of Del Monte sand led to the development of a glass with the following composition: (See Table II.)

		Composition No. 1
Silica	SiO_2	67.2 per cent
Alumina	R_2O_3	6.1
Lime	CaO	10.0
Alkali	Na_2O-K_2O	16.23
Sulfur Trioxide	SO_3	.27
Fluorine	F_2	.29
Boric Oxide	B_2O_3	.24
Density/Grams/cc		2.5180
Coefficient of Expansion 0-350° C		95.6x10-7
Working Properties:		

Table II

	Glass No. 1 Per Cent	No. 2 Per Cent	No. 3 Per Cent	No. 4 Per Cent	No. 5 Per Cent
Silica	67.2	72.2	66.8	66.0	68.9
Alumina	6.1	2.0	6.76	9.46	5.62
Lime	10.0	10.6	8.77	7.16	9.90
Barium Oxide			.57	.35	.26
Sodium Oxide	15.04	14.0	15.15	14.61	13.63
Potassium Oxide	1.19	.5	1.40	2.0	1.21
Boric Oxide	.24	.2	.19	.19	.21
Sulfur Trioxide	.27	.19	.26	.12	.13
Fluorine	.29	.25	.09	.26	.19
Density	2.5180	2.4958			
Softness Temperature Log Viscosity 7.65	1314°F	1324°F	1326°F	1335°F	1339°F
Annealing Point Log Viscosity 13.4	997°F	1002°F	1006°F	997°F	1026°F
Strain Point Log Viscosity 14.6	941°F	946°F	948°F	938°F	954°F
Gob Temperature		2133°F	2129°F	2250°F	2215°F
Relative Machine Speed		106	109.5	108	
Working Range Index		180	179	185	

	Log Viscosity	Temperature
Softness Temperature	7.65	7314° F
Annealing Point	13.4	997° F
Strain Point	14.6	941° F
Gob Temperature		
Relative Machine Speed		104

Expressed in operators' language, the glass was softer than most glasses on the West Coast. The gob temperature was about 20° F. lower than the average. The relative machine speed was about 4 per cent slower.

The working characteristics were not ideal, but did not pose a real problem. Production efficiencies were held between 80 per cent and 90 per cent and speeds were near the average of the industry. It was found, however, that the fining characteristics of the glass were satisfactory at low pulls and unsatisfactory at pulls of less than 6.0 square feet. Operating temperatures had to be abnormally high and taxed the performance of furnace refractories. As the furnace life increased, it became difficult to maintain the temperatures. The glass quality became bad and seedy. This necessitated a new glass composition with more favorable fining characteristics.

The below-listed composition was adopted. Del Monte sand was used as the source of alumina in the batch. (Refer to Table II.)

Composition No. 2		
Silica	SiO_2	72.5 per cent
Alumina	AL_2O_3	2.0
Lime	CaO	10.6
Sodium Oxide	Na_2O	14.0
Potassium Oxide	K_2O	.5
Boric Oxide		.2
Sulfur Trioxide		.19
Fluorine		.25
Density		2.4958

Working Properties:

	Log Viscosity	Temperature
Softness	7.65	1324° F
Annealing Point	13.4	1002° F
Strain Point	14.6	946° F
Gob Temperature		2133
Relative Machine Speed		106
Working Range Index		180

The composition was satisfactory with respect to fining characteristics and workability. However, the great usage of Nevada sand increased the costs tremendously.

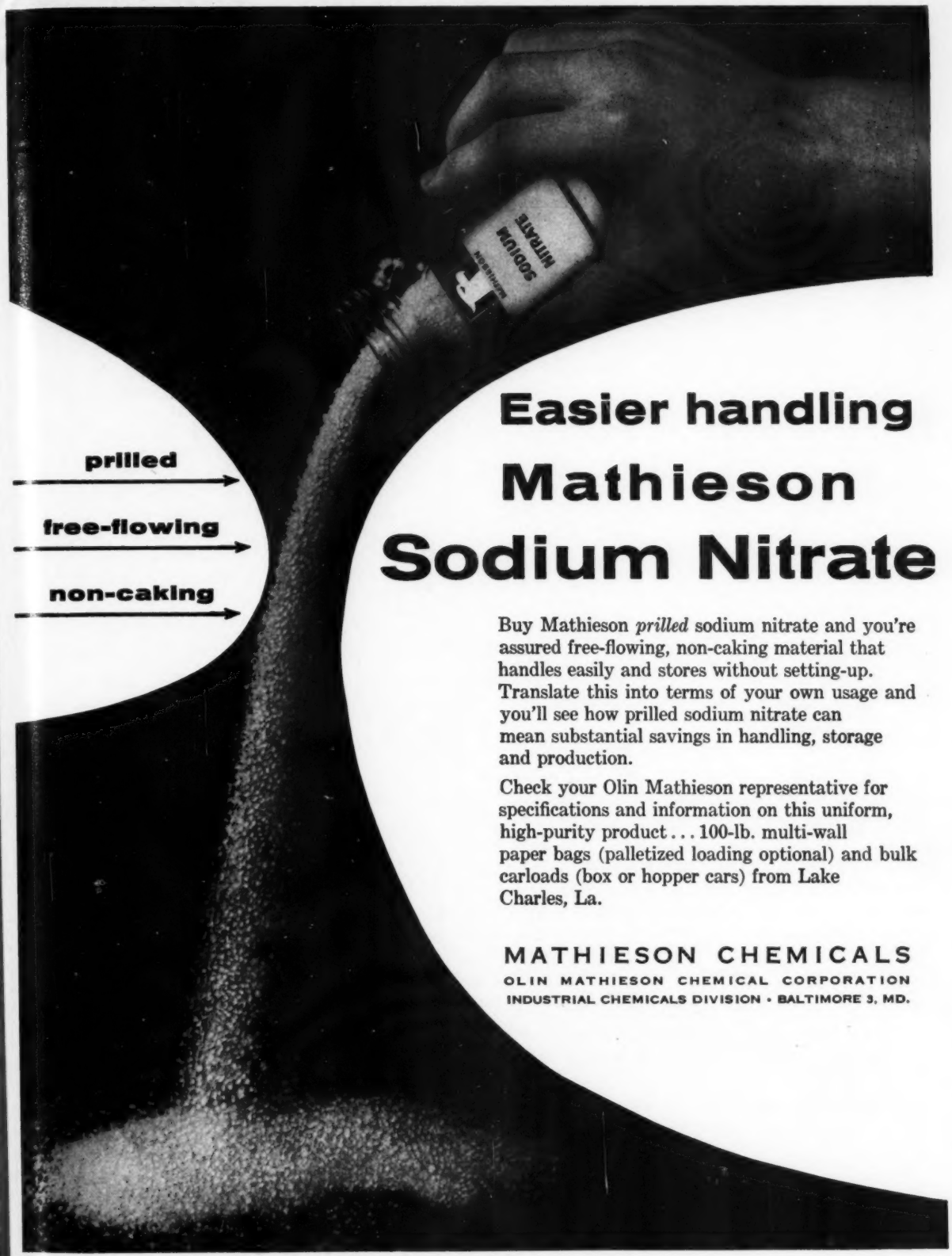
As mentioned, the flotation process of the Del Monte Sand Company permitted the processing of a sand with a predetermined and controlled alumina content. The low freight cost of this sand as compared with the freight from Nevada made the study of the 100 per cent use of this sand most interesting.

The use of the sand presented two major unknowns: The uniformity of the sand with respect to the alumina content, and the characteristics of the glass with respect to melting and fining. After many trial melts and fining test the following composition was adopted: (Refer to Table II.)

Composition No. 3		
Silica	SiO_2	66.8 per cent
Alumina	AL_2O_3	6.76
Lime	CaO	8.77
Barium Oxide	BaO	.57
Sodium Oxide	Na_2O	15.15
Potassium Oxide		1.40
Boric Oxide		.19
Sulfur Trioxide		.26
Fluorine		.09

	No. 1	*No. 2*	*No. 3*	*No. 4*
Coefficient of Expansion 0-350°C	99.6×10^{-7}			100.7×10^{-7}
Softness Temperature (Log Viscosity 7.65)	1344°F	1341°F	1332°F	1287°F

(*Continued on page* 512)



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Raw Materials of California . . .
(*Continued from page* 510)

Annealing Point (Log Viscosity 13.4)	1013°F	1020°F	1011°F	968°F
Strain Point (Log Viscosity 14.6)	955°F	964°F	955°F	912°F
Gob Temperature	2155°F	2140°F	2133°F	2147°F

Batch calculations to produce a similar glass indicated that with a 100 per cent use of Del Monte I.F. sand, further savings in glass costs could be realized. After a glass was developed it was found that the savings were of a magnitude of $75,000 to $100,000 per year. Again, melting and fining tests were carried out and a new glass was developed. Although difficulties were at first encountered with the melting and fining of the glass, minor modification corrected these problems. Performance of the glass was satisfactory. (See Table II.)

Composition No. 4

Silica	SiO_2	66.0 per cent
Alumina	AL_2O_3	9.46
Lime	CaO	7.16
Barium Oxide	BaO	.35
Sodium Oxide	Na_2O	14.61
Potassium Oxide	K_2O	2.0
Boric Oxide	B_2O_3	.19
Sulfur Trioxide	SO_3	.12
Fluorine	F_2	.26

Working Properties:

Softness	7.65	1326°F
Annealing Point	13.4	1006°F
Strain Point	14.6	948°F
Gob Temperature		2129°F
Relative Machine Speed		109.5
Working Range Index		179

The performance of the glass was rewarding in most respects. Particularly attractive were the savings in the glass costs which amounted to approximately $66,000 per year. The melting and fining characteristics were excellent at very high pulls. The working properties of the glass permitted machine speeds above the average of the industry. However, it should be mentioned that difficulties were initially experienced in the machine operation.

During this period the Del Monte sand was used on a 100 per cent basis in a container plant as well as the No. 66 sand. Table III illustrates glass compositions of the West Coast.

West Coast Glasses—San Francisco Area
1952-1955

	No. 1	No. 2	No. 3	No. 4
Silica	64.3	63.8	67.2	67.0
Alumina & Iron	9.18	9.58	6.42	6.76
Calcia	8.82	8.97	9.37	6.41
Magnesia	.....	.....	.....	.....
Barium Oxide	.13	.03	.03	.60
Sodium Oxide	15.42	15.50	15.26	17.31
Potassium Oxide	2.00	1.90	1.38	1.36
Boric Oxide	.03	.00	.....	.20
Sulfur Trioxide	.15	.21	.31	.33
Fluorine	0.00	.00	.....	.02
Density	2.5196	2.5208	2.5125	2.4995

	Log Viscosity	Temperature
Softness	7.65	1335°F
Annealing Point	13.4	997°F
Strain Point	14.6	937°F
Gob Temperature		2250°F
Relative Machine Speed		108
Working Range		185

The development and experience with high alumina glasses covered heretofore extended over a period of ten years. This development created problems in furnace opration, refractories, machine operation, and mold design. The problems encountered were too numerous to recite in detail. Credit is due the Hartford-Empire Company for the detailed investigations involved in the development of the glass compositions.

A presentation of this nature is limited in its scope, and there is a tendency toward over-simplification and generalizations. However, certain phases of a container operation are so complex as to permit generalization only. This holds particularly true of machine operation and mold design. Since there are no universally accepted methods to evaluate the working properties of glass, we must be content with the observations of competent operators. Unless a glass can be satisfactorily worked on the machine, the development is of academic interest only. This was accomplished with the above glasses. The collective comments of production people should be of interest.

As a rule, higher gob temperatures are required. The gob temperature has to be uniform and even, and can

Table III

West Coast Glasses—San Francisco Area
1952-1955

	No. 1 Per Cent	No. 2 Per Cent	No. 3 Per Cent	No. 4 Per Cent
Silica	64.3	63.8	67.2	67.0
Alumina and Iron	9.18	9.58	6.42	6.76
Calcia	8.82	8.97	9.37	6.41
Magnesia	.....	.....	.....	.....
Barium Oxide	.13	.03	.03	.60
Sodium Oxide	15.42	15.50	15.26	17.31
Potassium Oxide	2.00	1.90	1.38	1.36
Boric Oxide	.03	.00		.02
Sulfur Trioxide	.15	.21	.31	.33
Fluorine				.02
Density	2.5196	2.5208	2.5125	2.4995
Coefficient of Expansion 0-350°C	99.6×10^{-7}			100.7×10^{-7}
Softness Temperature	1344°F	1341°F	1332°F	1287°F
Log Viscosity 7.65				
Annealing Point	1013°F	1020°F	1011°F	968°F
Log Viscosity 13.4				
Strain Point	955°F	964°F	955°F	912°F
Log Viscosity 14.6				
Gob Temperature	2155°F	2140°F	2133°F	2147°F

(*Continued on page* 514)

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Hot Load—ASTM C 16-49	2640° F.	0.3% Deformation
	2900° F.	1.1% Deformation
Reheat Change—ASTM C 113-46	2910° F.	0.11% Linear Shrinkage
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(*Continued from page* 512)

Table III
West Coast Glass Compositions

Oxide	No. 1	No. 2		No. 3		No. 4		No. 5
	Flint Per Cent	Flint Per Cent	Amber Per Cent	Flint Per Cent	Amber Per Cent	Flint Per Cent	Georgia Per Cent	Flint Amber Per Cent
SiO_2	71.14	68.89	70.39	69.3	70.5	72.9	70.8	70.7
AL_2O_3	3.03	3.09	3.15	3.06	3.16	3.06	3.24	3.3
Fe_2O_3	.044	.050		.040		.041	.055	
CaO	9.23	10.22	8.99	11.27	10.41	10.81	10.87	10.4
MgO	.09	.21	.15	.15	.11	....	....	.1
Na_2O	13.5	14.87	14.79	13.43	13.65	12.64	12.55	13.1
K_2O	2.28	1.93	2.18	2.12	1.82	.68	2.32	2.0
B_2O_3								.2
SO_3	.08	.3	.01	.17	.05	.15	.22	.25
BaO	.12	.66	.36	.14	.08			

only be maintained with automatic forehearth control. The gob shape itself has to be longer and smaller in diameter as compared with normal glass.

The loading of the gob is very critical. Drop guides must be in perfect alignment. It is also important that the delivery equipment fits the gob size which necessitates changes of deflectors with almost each job change. The entire forehearth operation must be more exacting. Plunger shape and size are equally important, and require changes much more frequently than with a normal glass. Similar modifications are necessary in mold design and machine operation. Precision fits are required in mold equipment, with more frequent changes. Blanks are, as a rule, smaller. In general, more reheat time and less blank time are required with the reheat time about 50 per cent of the blow time.

Southern California

The proximity of the Corona sand deposit to the glass plants in Southern California, with subsequent low freight rates, eliminated the Nevada sand almost entirely. As can be seen in Table III the glass compositions given are very similar.

Although the container glasses of Southern California cannot be considered high alumina glasses, the alumina content is higher than generally found in the industry.

A few words about the melting, fining and working characteristics of the glasses might be of interest. The melting and fining rates appear to be somewhat superior to batches with silica sand. This is especially noticeable at higher pulls. The forming rates are higher with equally higher gob temperatures.

Conclusion

The author recognizes that this paper is not as scientific and technical as it might be. However, it is hoped that the information presented, although general in nature, will be of interest. Perhaps this paper contains a hidden message to the flat glass people in that there is an abundance of raw materials for glass manufacture on the West Coast. Furthermore, it might point out a new approach to raw materials and glass technology to those who are and will be burdened with increasing raw material costs.

LOUIS NEUBERG, OF FMC, DIES

Louis Neuberg, vice president in charge of sales for the Chemical Divisions of Food Machinery & Chemical Corporation, died July 30 at his home in Colonia, New Jersey. He was sixty-five years old. Mr. Neuberg came to FMC in 1948 when it merged with Westvaco Chemical Corporation. At that time he was vice president in charge of sales for Westvaco.

Mr. Neuberg began his career with Westvaco in 1914, when he joined the predecessor firm, Warner Chemical Company. In 1922 he became resident manager of Warner's Carteret, New Jersey plant. In 1930 he transferred to the New York office as vice president and sales manager. In 1935 he became a director of Warner's successor firm, Westvaco Chemical Corporation, and became vice president in charge of sales in 1936.

Mr. Neuberg was co-owner with his brother, Frederick, of Enco Chemical Company, a chemical brokerage and importing and exporting firm founded by their father, William Neuberg.

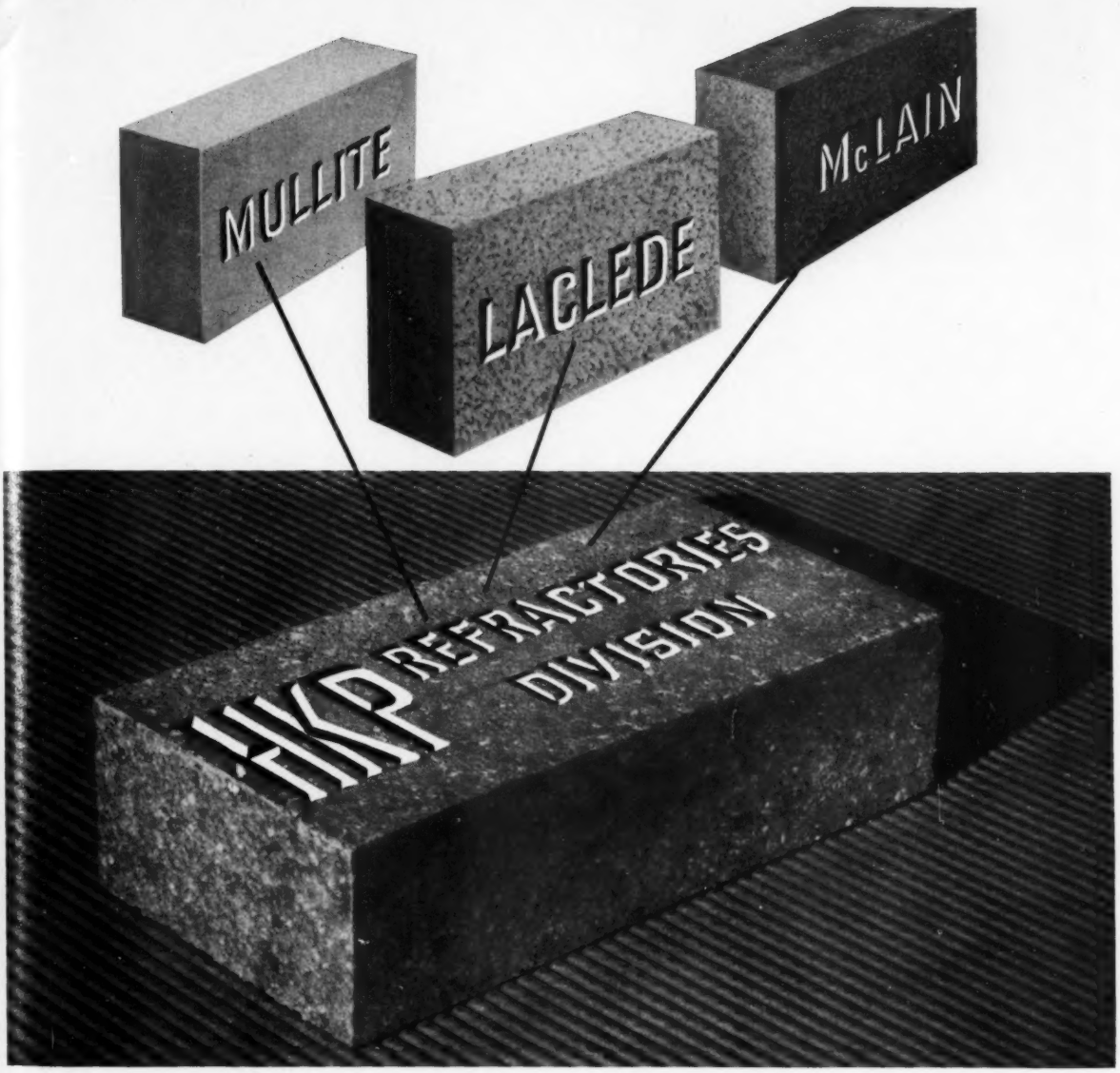
Widely known throughout the industry, Mr. Neuberg for many years had been actively associated with chemical groups and organizations. He was a member of the Chemists' Club, the Salesmen's Association of the American Chemical Industry, the Union League Club, the Cloud Club, and the Colonia Country Club. He is survived by his wife, Lillian, and his brothers, William D. and Frederick A.

CORHART MARKETS NEW REFRACTORY

High temperature, corrosion resistant refractories for the glass industry, manufactured by Corning Glass Works, will be marketed by Corhart Refractories Company beginning August 1, it was recently announced.

The statement was made jointly by Hugh L. Kline, president of Corhart, and Edward C. Leibig, manager of Corning's Refractories Division. Corhart is a wholly owned subsidiary of Corning Glass Works.

Corning Glass Works has been making refractories for its own use for over 50 years. The Refractories Division was established less than two years ago to sell refractories externally.



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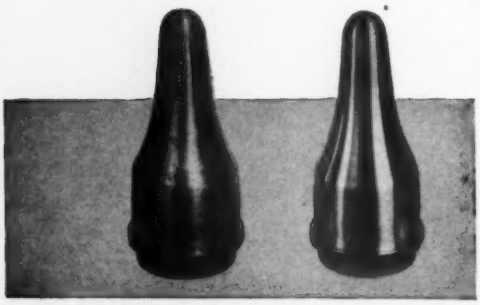
THERMOSPRAY coated mold plungers give 8 times longer service life

Important savings are being made in production down-time and replacement-part costs on equipment subject to heat and abrasion. Typical of these are mold plungers like those shown here which are being THERMOSPRAY coated by glass manufacturers for protection against heat corrosion. Other advantages include improved product quality, with better finish on glass parts. Longer production runs are feasible without dismantling machines.



Before (left) and after (right) coating with METCO *ThermoSpray* Process. Users report coated plungers last average of 8 times longer than uncoated. Parts finish is improved, production down-time reduced.

The new METCO THERMOSPRAY Process consists of spraying specially developed alloys in powder form with the METCO THERMOSPRAY GUN. These alloys are of the nickel-chrome-boron type and are self-fluxing. No compressed air is required. Coating hardnesses range from Rc 30 (machineable) to Rc 65, depending on the specific THERMOSPRAY alloy used; will even outwear hardened steels from 3 to 10 times. Spraying speeds are higher – 8 to 10 lbs. per hour – and deposit efficiency far greater (up to 97%) – than with any other type of available equipment.

Application of these materials in powder form permits close control of the amount applied and leaves a comparatively smooth surface that requires a minimum of finishing compared to other methods of application.

Free bulletin – write today for Bulletin 126 which illustrates and describes the METCO ThermoSpray Process or ask for a call by a full-time, company-trained Metco Field Engineer in your territory.

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Fining . . .

(*Continued from page* 493)

by 4 dynes/°C. The phenomenon has been described by Jebsen-Marwedel[29].

The film of glass which surrounds the part of the bubble emerging from the glass melt can, by loss of heat, assume another temperature and, thus, another viscosity and another surface tension from those of the remaining glass. It has not yet been clearly explained if the bursting of the bubble is thus retarded. Jebsen-Marwedel[24] presumes that the occasional arrival of layers rich in bubbles near the surface of the glass, for example in the cooling zone of tanks for drawn flat glass, can be explained by the fact that the surface glass cools first so that rising bubbles cannot pass through this cooled layer and gradually join each other in the neighborhood of the surface.

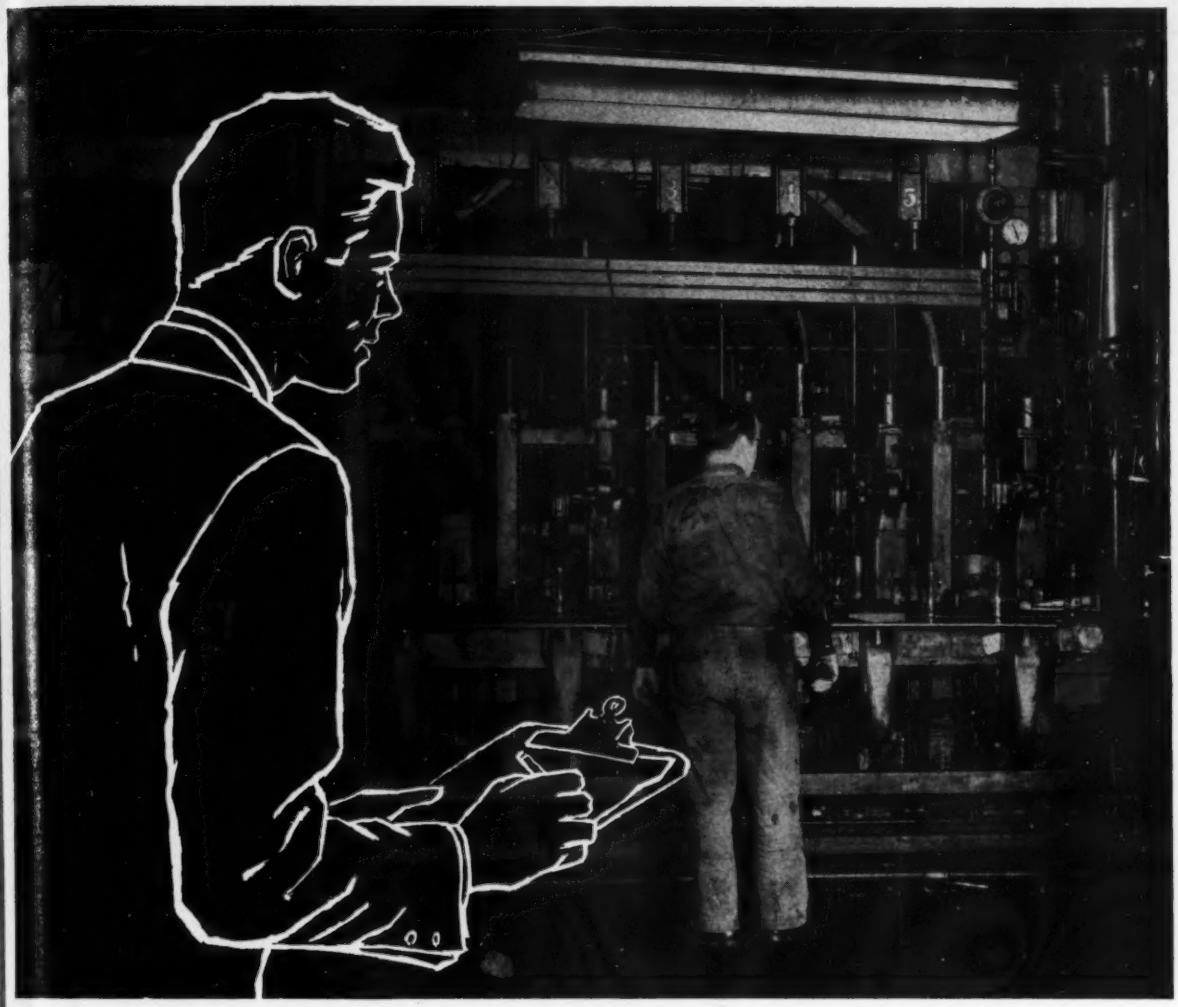
4. Homogenization

One must consider that the principal function of rising bubbles in the glass is their homogenizing action. Jebsen Marwedel has shown that a bubble is able to greatly deform a layer of striae. Neither displacement nor mixing with turbulence is produced for, as has already been shown, there can exist only a laminar flow. More exactly, the bubbles during their ascent draw out the striae with which they have come in contact so that, for example the striae which at first were placed horizontally, are deformed toward the vertical in the vicinity of the bubble and are even drawn away and separated from one another. The homogenizing effect rests on the fact that the resisting films of the striae are drawn transversally to their plane while becoming very thin without breaking. When numerous bubbles repeat this action, it greatly dislocates every layer consisting of striae and forms an extremely divided surface.

The diffusion of the striated glass into the base glass thus creates a surface which is incomparably larger than that which existed before the action of the bubbles. Thus, the preliminary conditions favorable to the desired homogenization are realized. The considerably enlarged surface areas thus created undergo, in addition, the effect of the surface tension, of the osmotic pressure, etc. The result of these phenomena is comparable to that of a powerful agitation in the glass melt. According to Wo. Ostwald[32] the division of the striae and of the heterogeneities in the glass, which is produced under the action of the bubbles, can be qualified as "difform", a term formed from the words "diffusion" and "deformation" and should mean that by deformation, a division takes place which activates the diffusion in a decisive manner. The different glasses (striae) existing beside one another will be more easily rendered homogeneous in the same proportion that their "difformation" is stronger.

At times one is tempted to consider homogenization as a separate phenomenon, because one presumes that in the elimination of heterogeneities contained in the glass not only do the movements created by the rising bubbles participate, but also other movements participate, such as convection currents in tanks or the swirling of striae described by Jebsen-Marwedel. There is still insufficient data on the homogenizing effect of thermal currents in glass. It is undesirable, without doubt, for the return

(*Continued on page* 526)



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The FORMASIL Spray Kit permits the automatic application of silicones on shears, in scoops, deflectors and blank molds. Developed by the UNION CARBIDE Silicones Man with the assistance of Wheaton Glass Company, Millville, N. J., the efficiency of the system was demonstrated and proven during a *two week production run!* Today, after four months of using silicones continuously, smoke, soot and dirt are greatly reduced . . . blank mold swabbing and changing decreased by better than 50 percent! The job speed increased and percent pack is equal to or better than any previous performance!

You can install the FORMASIL Spray Kit (includes all fittings and instructions) on your Hartford Empire I.S. machine. And, your UNION CARBIDE Silicones Man can give you data about kits under development for other types of glass forming equipment. Call the Silicones Man today . . . or write Dept. GL-9, Silicones Division, Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y.

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Shadograph scales can be calibrated to hundredths of an ounce—with accuracy to .01 ounce. They not only indicate empty bottle weight but also permit the operator to determine the capacity of the container by the gravimetric method—determining fluid ounce capacity by weight. Models are designed specifically for the glass industry. Write for Bulletin 3333.

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BETTER QUALITY CONTROL . . . BETTER COST CONTROL

Inventions and Inventors . . .

(*Continued from page* 504)

of 30 cms. and the following compositions.

	Per cent
(a) Sand (similar to the sand used at the end of the grinding operation as usually effected)	65 to 55
Sawdust	12
Polyvinyl acetate	15 to 25
(b) "Rouge"	60 to 50
Sawdust	15
Polyvinyl acetate	25 to 30

A finish was obtained quite similar to that normally secured with 25 tools as usually used (each including three rotating discs arranged around a rotating shaft) and with an advance of the work of 300 cms. per minute and a linear velocity of tool of 4 m. per second. In this test four sand tools (a) and 10 rouge tools (b) only were used.

There were 18 claims and 28 references cited in this patent.

Miscellaneous Processes

Edge Grinding Optical Lenses. Patent No. 2,748,541. Filed Feb. 5, 1953. Issued June 5, 1956. Three sheets drawings; none reproduced. By Wade Hampton Connell.

This invention relates to edge grinding optical lenses and more particularly to an apparatus and method for forming under automatic control a desired configuration at the peripheral edge of the lens.

A lens grinding device is devised in which the lens is revolved against the circular edges of a pair of closely overlapping abrasive discs at the apex formed by their converging circumferences. The axis of the revolving lenses is radially controlled to follow in grinding contact with the apex according to the sinuous curvature of the peripheral edge of the lens. A particularly important result of the invention is to minimize or eliminate the necessity of dressing the circular abrasive discs since they are self dressing during their wear and will cut uniformly excellent edges and bevels upon a multiplicity of consecutively treated lenses.

There were nine claims and the following references

(*Continued on page* 524)

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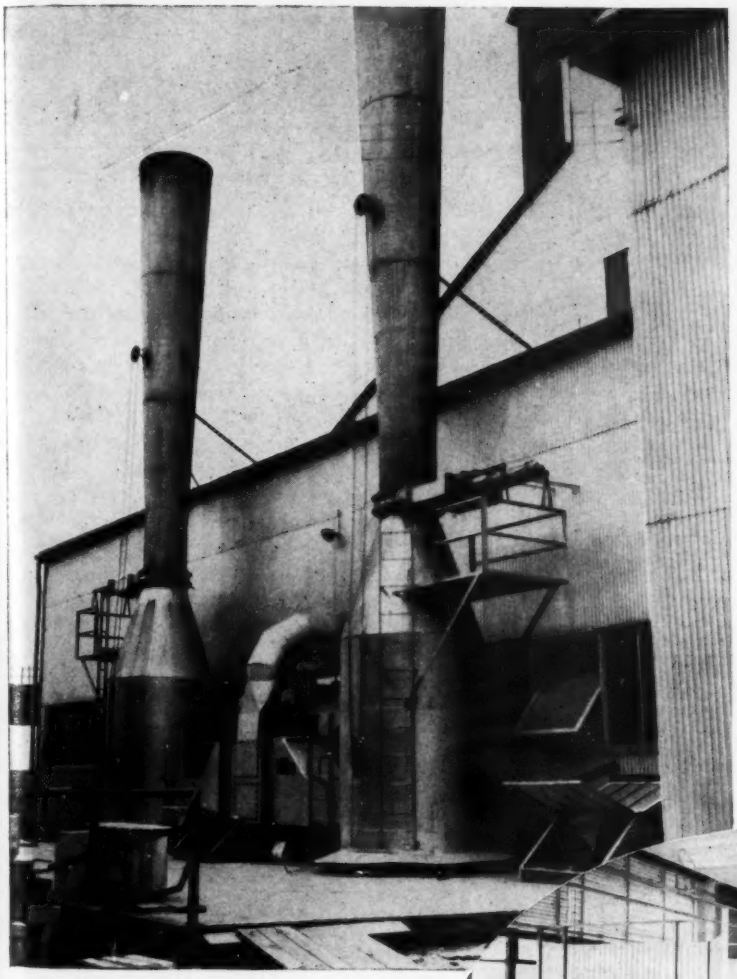

Morgan-Isley Ejector installation at Mississippi Glass Co., St. Louis, Mo., world's largest manufacturer of rollec glass. Inset shows one of Mississippi Glass products in use as office partitions.

In commenting on the Morgan-Isley installation at his company's St. Louis plant, Mr. Ellis Humphreys, Vice President of Mississippi Glass Co. said, "An ejector stack is far less temperamental than a natural draft stack, and, of course, is much less costly to build.

"One of the great advantages of the Morgan-Isley system comes from the secondary checkers. These give the incoming air a fine prewarming before it goes into the regular checkers. This not only results in better furnace operation, but seems to keep the regular checkers in much better condition. Incidentally, the secondary checkers seem to last indefinitely, and don't need to be cleaned during repairs. This system is good and greatly improves furnace operation."

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Inventions and Inventors . . .
(*Continued from page* 518)

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L. W. ROOT NAMED BEHM RESEARCH DIRECTOR

Lloyd W. Root, former associate professor of physics at the University of Dayton, has been named director of research for the precision optical glass division of George Behm & Sons Company, Dayton, Ohio.

For the past six years, Root has assisted the glass processing firm as consultant on special optical testing and fabrication problems, chiefly those involving windows in photo-reconnaisance air craft.

The division, one of five Behm sections devoted to various phases of glass production, is also responsible for fabricating glass filters, reflector plates, and Schlieren windows.

A graduate of Lawrence College, Appleton, Wisc., Root finished his post-graduate work at the University of Chicago in 1935. Since that time, he has served as both an educator and an industrial research consultant to such firms as General Electric Company, Fox Film Corporation, Kimberly-Clark Corporation, and Standard Electrical Products Company. He joined the University of Dayton staff in 1949.

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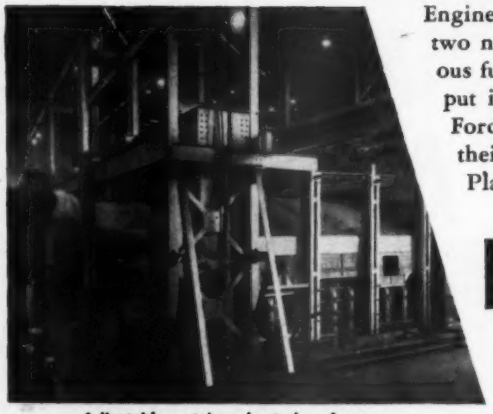

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Calumite, in delivering these "extras", helps to eliminate the hidden costs in raw materials.

The Calumite Co.
HAMILTON, OHIO

Fining . . .

(*Continued from page* 516)

flow to carry fined glass to the region of the melting zone and batch to unfined glass. It is still not well known if Preston's[33] presumption is right that homogenization would be produced in the area between the flow directed toward the working zone and the return flow, as well as in other swirling zones.

On this subject one cannot pass quietly over the fact that the strong gas evolution which already took place at the time of fusion has a homogenizing action and thus carries a part of the work which is necessary for fining.

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(*Continued on page* 528)

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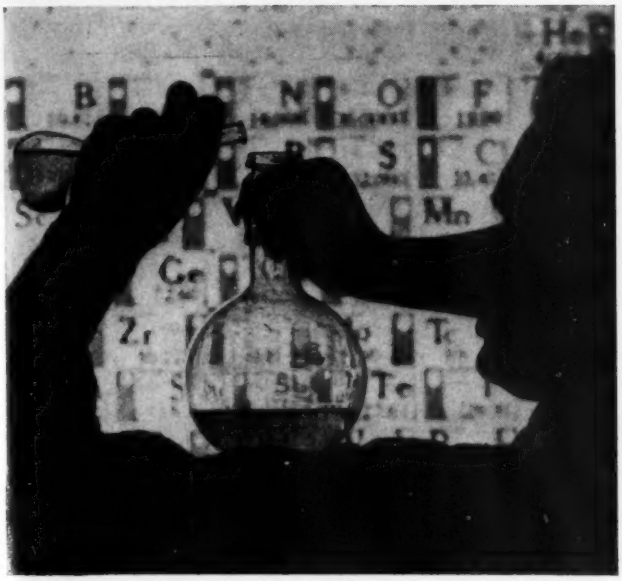

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